...GY OF THE DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

THIRD YEAR FINAL REPORT

NOVEMBER 1983

BY
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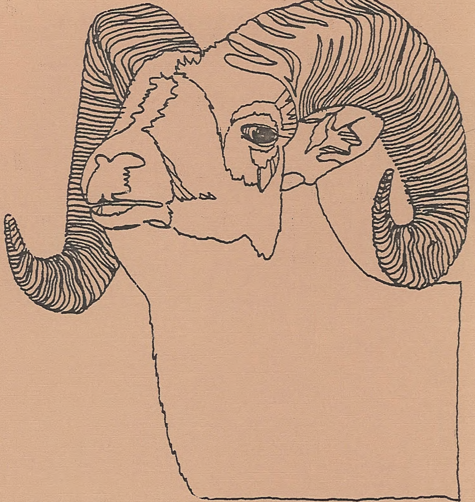

BUREAU OF LAND MANAGEMENT UTAH

THIRD YEAR FINAL REPORT

THE ECOLOGY OF THE DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

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ABSTRACT

Phase 3 of the study of the ecology of desert bighorn sheep on Bureau of Land Management administered lands in southeastern Utah began December 1, 1982, and continued through November 30, 1983. An additional 12 bighorn (2 rams, 10 ewes) were captured and collared with radio transmitters January 30-February 1, 1983, to increase the number of collared bighorn being monitored to 22. Bighorn ram home ranges were found to be greater than ewe home ranges in the study area. Rams showed high fidelity to breeding areas and ewes showed high fidelity to lambing areas. Desert bighorn selected primarily Chinle and Moenkopi talus slopes and Shadscale-Galleta-Ephedra grass and Pinyon-Juniper vegetation types. All slope aspects were utilized, but southeast, southwest, northwest and south facing slopes were most often selected. Forage selection by bighorn differed seasonally, however, browse was the most common selected forage class in all seasons. Cattle and bighorn diets overlapped in forage taxa selected, but proportion of various items in cattle and bighorn diets differed significantly. Cattle and bighorn were found to use available topographic types differently during the grazing season. Cattle selected lower talus slopes and valley floors and bighorn selected higher talus slopes. There was no evidence to suggest bighorn used the habitat differently before and after cattle were moved into the area. Bighorn response to boat, vehicle, hiker, and aircraft disturbance was monitored. Bighorn showed little response to boats unless boats landed and people approached on foot. Bighorn response to vehicular disturbance was dependent on group composition, group size and distance to disturbance, however, bighorn response to hiker disturbance was dependent only on group size of bighorn.

Telemetry flights did not cause extraordinary movements by bighorn after being disturbed by the plane. Desert bighorn were found to have positive titers for blue tongue (33%) and contagious ecthyma (93%) but negative for anaplasmosis, brucellosis, leptospirosis, and vesicular stomatitis. One of 9 hunter-killer rams was infected with a mild case of scabies ear mites.

ACKNOWLEDGEMENTS

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The Utah Division of Wildlife Resources has also provided much assistance to the project. The vehicle and living quarters used by the researchers were provided by the UDWR. Jim Bates, Southeast Region Game Manager, and Derris Jones, Southeast Region Game Biologist, captured and collared the bighorn sheep; an often dangerous task. Val Judkins, UDWR pilot, flew monthly fixed-wing telemetry flights throughout phase 3 of the study.

Special thanks goes to Jack Conroy, helicopter pilot, for his expertise in getting us to where the sheep were.

Thanks also goes to Canyonlands National Park personnel, especially Tom Wylie asnd Sandra Halloway, for their cooperation in providing information regarding recreation activities in the area.

Dr. Robert Hedelius, U.S. Department of Agriculture Veterinarian, collected and analyzed blood samples collected from desert bighorn sheep.

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INTRODUCTION

Purpose

The desert bighorn sheep (*Ovis canadensis nelsoni*), native to the harsh canyon country of southeastern Utah, is one of the most sought after game animals in North America for consumptive as well as nonconsumptive purposes. As a component of arid and often times fragile desert ecosystems, it requires close management as our human population expands its realm of use into bighorn sheep habitat for mineral exploration and extraction, livestock operations, recreation opportunities, etc. Expanded human use into bighorn habitat necessitates good research to determine ecological requirements of the bighorn so that critical components may be protected and conserved to insure that the desert bighorn sheep will always be a part of our desert ecosystems.

Desert bighorn sheep have been studied extensively by several researchers in Utah during the past 15 years. Wilson (1968) conducted the first study on desert bighorn sheep in Utah. His pioneering study was conducted primarily in the rugged canyons of San Juan county, Utah, particularly in the area of Red and White Canyons. He concluded that the population was static as a result of several limiting factors including: 1) lack of available water, 2) competition with cattle and deer, 3) internal parasites, and 4) high lamb mortality. Wilson also believed that lambing grounds were traditional, with ewes using the same area for lambing year after year. Irvine (1969) in a follow-up study to Wilson's, concluded that in the Red Canyon area there was no migration of desert bighorn sheep but that seasonal movements due to the availability of water did occur. Contrary to Wilson, Irvine felt that

lambing grounds were not traditional and that the population was growing as a result of low lamb mortality. Differences seen by Wilson and Irvine may be attributable to low precipitation during Wilson's study compared to relatively high precipitation during Irvine's study.

Bates et al. (1975) conducted the first telemetry study on Utah's desert sheep in the same general areas as the previous studies as well as the Glen-Dark Canyon areas to the north. Radio-collared sheep were monitored via fixed-wing aircraft from 1972-1975 in an effort to learn more of the sheep's seasonal movement and distribution. They found that the rams occupied generally larger home ranges and higher elevations than the ewes.

Dean (1977) conducted the first study on the ecology of desert bighorn sheep in Canyonlands National Park, Utah. He was primarily concerned with the distribution and abundance of sheep within the park. He felt that human and livestock activities in the park were limiting bighorn distribution and recommended that livestock grazing be discontinued within park boundaries. He also found no migration of sheep but did observe seasonal movements by rams before and after the rut as they moved to and from areas of ewe concentration for breeding, similar to the patterns observed by Wilson (1968) and Irvine (1969).

Although these early studies provided much needed baseline data on sheep distribution and abundance, life history, and behavior, there remain many questions concerning the ecology of the desert bighorn sheep in Utah that remain unanswered. For example, there has never been an intensive follow-up study in the Red-White Canyon area since Irvine completed his work in 1969. Information on current status of sheep movements, abundance and distribution, and population trend is sketchy

at best. Since that time, mining and recreation activities have fluctuated, while livestock uses have remained about the same. Mining exploration peaked during the late 1970's and has been declining since then. Recreational activity may have also declined during the same period. An intensive study with the aid of radio telemetry equipment and on-the-ground observations will allow assessment of current population trends and will help in providing data critical for development of the Bureau of Land Management's land use planning system, livestock grazing environmental statement, and for the best possible management of the desert bighorn sheep and its habitat under the multiple use concept.

This is a report on the progress of the third phase of the long term study of the ecology of desert bighorn on BLM lands in southeastern Utah.

Objectives

The third year's study effort with reference to the ecology of desert bighorn on Bureau of Land Management lands in southeastern Utah includes the following objectives:

1. Continue literature search.
2. Capturing and fitting additional desert bighorn sheep with radio transmitters.
3. Continue monitoring movements of bighorn both by aircraft and from the ground.
4. Gather physiological and disease information on captured sheep.
5. Continue to collect forage utilization data; including fecal samples.
6. Continue to collect data on the influences of recreational and mineral activities on bighorn sheep.
7. Continue to collect data on the influence of livestock grazing on bighorn sheep.

LITERATURE REVIEW

An on-going literature review process dealing with the various objectives of the study has been conducted throughout the study (King and Workman 1981, King and Workman 1982). Additional material not covered in those previous reviews is summarized in the following section.

Movements and Habitat Utilization

Welles and Welles (1961) found that bighorn sheep in Death Valley National Monument, California did not have large home ranges. Bighorn spent their entire lifetime within a 32 km radius. They also noted that movement patterns of bighorn prevented depletion of forage resources. Bighorn tended to leave a given area before it became overgrazed or dessicated. Blood (1963) noted a similar trend in Rocky Mountain bighorn that tended to follow the best foraging conditions, especially the green-up of succulent grasses and forbs. Irvine (1969) found a similar pattern for desert bighorn in Utah.

Jones et al. (1957) found that summer home ranges of desert bighorn in California were smaller than winter home ranges due to dependence on water sources. Wilson (1968) reported a similar pattern in Utah where bighorn in Red Canyon had smaller home ranges than bighorn in White Canyon. He felt that the difference was attributable to fewer permanent water sources in the Red Canyon area.

Movements were reported by Munoz (1982) for radio collared desert bighorn in New Mexico. He reported less movement by ewes than rams in his study area. Average distance between extremes of home ranges for ewes was 8 km and 19.1 km for rams.

King and Workman (1983a) reported desert bighorn rams had larger home range areas than ewes and apparent fidelity of rams to breeding areas and ewes to lambing areas.

Holl and Bleich (1983) found that the most important habitat component for bighorn sheep was escape terrain consisting of steep slopes with abundant rock outcrops. They also found that winter-spring ranges were between 900-1800 m elevation on southern aspects usually in Ceanothus-mountain mahogany vegetation. They calculated that approximately 245 ha of winter-spring range was necessary to support 10 bighorn. Summer ranges extended to 3300 m elevation and vegetation associations with less than 30 percent canopy cover and adjacent to escape terrain were selected. During fall, bighorn relaxed their affinity for escape terrain and a wide variety of vegetation associations were used, especially those that produced high mast crops.

Shannon et al. (1975) found that slope, distance to escape terrain, salt availability, elevation, aspect, forest cover, shrub productivity, bromass and nitrogen content of palatable grasses, and snow all affected seasonal distribution of Rocky Mountain bighorn sheep.

Forage Utilization

Food habits of sympatric feral burros (*Equus asinus*) and desert bighorn sheep were determined monthly during 1980 in the Cottonwood Mountains of Death Valley National Monument (Ginnett and Douglas 1982). Analysis of feral material indicated that bighorn and burrows utilized many of the same forage taxa, resulting in a moderate degree of dietary overlap. Bighorn maintained constant proportions of browse, grasses, and forbs in year-round diets, but the use of individual taxa varied

considerably through the year. Annual percentage in bighorn diets of browse was 55.51%, grasses 38.40%, and forbs 2.73%.

Seegmiller and Ohmart (1982) studied food habits of desert bighorn in western Arizona. It was found that during the summers of 1974 and 1975 adult and lamb diets differed significantly but that during spring 1975 adult and lamb diets did not differ. The relatively high abundance and quality of forage during spring 1975 promoted inter-age diet similarity. As desert forage died or entered dormancy, summer diets of adults and lambs diverged. They recommended that to maximize productivity and survival of desert bighorn, habitat managers must develop land-use guidelines designed to maximize availability of highest quality and most preferred diet species. For example: (1) restrict livestock grazing and other human induced disturbance, (2) expand range available to nursery bands by improving the number and distribution of watering sources, and (3) provide supplemental food that is high in nitrogen and digestability at key watering sites.

Influence of Livestock

Potential competitive interactions between bighorn and domestic livestock can involve direct competition for forage, water, space, etc.,or more subtle interference such as social intolerance or disease transmission.

Few, if any, manipulative studies involving removal of potential competitors from an area with subsequent monitoring of population responses of the remaining species have been conducted. This is, in no doubt, due to the economic impracticality of livestock permitees removing all livestock from their allotments for experimental purposes.

Therefore, most information available on this subject is based on circumstantial evidence. However, relatively reliable correlations can be made based on most of this information.

Goodson (1982) described a number of cases in which large scale die-offs of bighorn follow introduction of domestic stock onto bighorn ranges. Foreyt and Jessup (1982) described two instances of die-offs of bighorn sheep after coming in close contact with domestic sheep. The previously healthy bighorn died of acute fibrinopirulent bronchopneumonia shortly after contact with domestic sheep.

Lance et al. (1981) documented an occurrence of contagious ecthyma in a Rocky Mountain bighorn population in Colorado. Contagious ecthyma titers were not present in the bighorn population prior to introduction of a small band of domestic sheep in the area.

The U.S. Forest Service and California Department of Fish and Game have recommended that no domestic sheep grazing allotments be within 3.2 km of mountain sheep habitat based on the evidence mentioned above (Holl and Bleich 1983).

Influence of Human Disturbance

The influence of human disturbance on bighorn sheep is not well understood. Most available information is anecdotal in nature and often based on single observations. Few studies have been designed to systematically study effects of human disturbance on sheep; however, recently, more systematic investigations of human impact on bighorn have been conducted.

Welles and Welles (1961) have evidence that bighorn may be tolerant of human intrusion into their habitat. However, such tolerance of human

encroachment appeared to be highly variable from one group of bighorn to another and was related to degree of excitability of the group leader and probably the degree of stress under which the various groups were operating.

Effects of human disturbance on desert bighorn were studied in the San Gabriel Mountains, California, to determine if bighorn were abandoning habitat that received high levels of human use (Hamilton 1982, Hamilton et al. 1982, Holl and Bleich 1983). Bighorn were not prevented from using an important mineral lick, nor did they avoid it, but did use it only when no humans were in the immediate vicinity. They also found no difference in sheep distribution between a heavy recreation area (6404 hikers/season) compared to a light recreation area (24 hikers/season). They found no significant difference in distribution of sheep in close proximity to a mining road before and after its opening to traffic (traffic levels were relatively low, 2-4 trips/day). They concluded that bighorn have adapted to present levels of human use in the San Gabriels and are not adversely affected by the present levels of recreational use. However, they recommended that: (1) there should be no cross-country travel in bighorn summer range, (2) recreationists should stay on trails, (3) traffic levels on existing roads should be maintained at low levels (permitting gradual increase), (4) new roads and trails should not pass within 100 m of mineral licks, and (5) roads and trails that pass through known lambing areas should not have levels of traffic exceeding 1 group/4 hours, on a sustained bases, from April through June (lambing season).

Holl and Bleich (1983) found in the San Gabriels that bighorn were not negatively affected by ski facilities operated during winter months,

but recommended that they not be operated commercially during summer.

Specific negative impacts of humans have been found in several areas where humans have disturbed areas critical to bighorn survival. Particularly construction or disturbance at or near waterholes in Arizona, Nevada, and California. Campbell and Remington (1981) found that construction near watering sites caused shifts in bighorn watering patterns in the Buckskin Mountains, Arizona. Bighorn drank earlier or later than usual to avoid human contact at watering sites.

Leslie and Douglas (1980) showed that construction on a water project in the River Mountains, Nevada, caused bighorn to move to new areas and use new water sources.

Douglas (1976) cited an example of decreased use of 49 Palms Oasis, Joshua Tree National Monument, California, as a watering site by bighorn after a paved road and parking lot were developed in the area. The road was closed in 1974 and 1975 from May through August to reduce human intrusion into the area and sheep began to use the oasis again.

Disease and Physiological Information

Wildlife management agencies have recognized a need to understand the various mortality factors responsible for significant reductions in bighorn populations in North America. As a result, investigation into bighorn disease complexes, specifically isolation of causitive agents and development of treatments, has increased in recent years.

An intensive investigation is being conducted in California to determine causes of recent high lamb mortality in the Santa Rosa Mountains (DeForge and Scott 1982). High lamb mortality over the last six years has drastically reduced bighorn populations in that area.

Pathologic evidence suggests that lambs have been dying of pneumonia probably secondary to viral infections of parainfluenza-3, blue tongue, epizootic hemoragic disease, and contagious ecthyma (DeForge et al. 1982, Turner and Payson 1982). They did not, however, eliminate other factors such as nutrition, inter-specific competition, predation, changes in weather patterns, human impacts, etc. from consideration as possible causes of high mortality.

High lamb mortality caused by pneumonia was also found in Colorado bighorn herds (Woodard et al. 1974). Pneumonia in these sheep was caused by parasitic (Protostrongylus stilesi) and bacterial invasion of the lungs. Ewe:lamb ratios were reduced from 100:83 to 100:17 in 1969 and 100:72 to 100:22 in 1970 due to pneumonia infections.

Pneumonia also proved fatal to bighorn in California and Washington in 1979-80 (Foreyt and Jessup 1982). Acute fibrinopirulent bronchopneumonia followed contact with domestic sheep in two separate cases suggesting pathogenic bacteria were transmitted by domestic sheep to bighorns.

Psoroptic scabies infections have been a serious detriment to bighorn population in the past (Jones 1950, Cater 1968, Follows 1969, Lange et al. 1980). Recent evidence suggests that scabies have been partially responsible for declines in desert bighorn numbers in Nevada (Lange et al. 1980) and Arizona (Welsh and Bunch 1982). In both areas, bighorn populations were down considerably after high incidence of scabies was reported for the area.

Contagious ecthyma is a disease of some interest presently. Several clinical cases of a mouth disease, suspected to be contagious ecthyma were observed in desert bighorn sheep in Utah during fall 1982

(King and Workman 1982, King and Workman 1983b). The disease ran a benign course and no mortalities were observed; however, fatalities of bighorn lambs in California from pneumonia are possibly caused by previous infections of contagious ecthyma (DeForge et al. 1982). Titers for contagious ecthyma have also been found in New Mexico (Sandoval 1983, personal communication) and Arizona (Remington 1983, personal communication), indicating its widespread occurrence in the western United States. Clinical cases of contagious ecthyma have been discovered recently in Rocky Mountain bighorn (Lance et al. 1981) where it is thought that domestic sheep were the source of the virus and in Dall's sheep (Smith et al. 1982). The virus attacked the mammary glands and teats of one captured ewe at Sheep Creek, Alaska. Although contagious ecthyma can cause death, the primary concern is that severe contagious ecthyma infections may predispose bighorn to secondary invasions by pneumonia causing agents.

Relatively low positive titers of leptospirosis, a cause of abortion, infertility, and neonatal death, were found in desert bighorn sheep in Arizona (Chilleli et al. 1982). However, low titer levels in conjunction with no apparent problems with infertility or abortion in the sampled areas indicate that leptospirosis is not a problem at present.

Glaze et al. (1982) reported a surgical treatment for chronic sinusitis tumors. The infected tissue of a ewe collected in Utah was removed surgically and the ewe recovered after 4-6 weeks post-operative treatment. The procedure could prove useful in treating cases of chronic sinusitis that haven't progressed to extremes.

STUDY METHODS

Description of Study Area

Immediately south of Canyonlands National Park in southeastern Utah, the Bureau of Land Management administers extensive acreages of public land that provide suitable habitat for desert bighorn sheep. The bighorn sheep study area proper (Figure 1) is encompassed by the following boundaries:

1. south boundary - south rim of Red Canyon, Utah Highway 263
2. east boundary - Manti-Lasal National Forest
3. north boundary - Canyonlands National Park
4. west boundary - Glen Canyon National Recreational Area

The study area is composed of some of the most rugged desert terrain found anywhere in the United States. Topography throughout the area is rough and broken. Canyons are very precipitous and not easily accessible to human use. Talus slopes and boulders are common throughout the canyons, with many slopes exceeding 100 percent grades.

The topography within the area varies considerably from region to region. The southern region of the study area (Red Canyon, White Canyon, Jacobs Chair) is characterized by high mesas and buttes of sandstone cliffs and talus slopes rising as much as 2,000 feet from rough broken canyon bottoms. The northern region (Dark Canyon, Bowdie Canyon, Gypsum Canyon), though in rather close proximity, is constrastingly different in structure. Most striking about the northern region are the extremely deep, precipitous gorges falling as much as 1,500 feet from the rim tops to the Colorado River and its tributaries.

The soils of the area are usually shallow and not well developed.

Plant communities in the study area are typical of the Upper and

Lower Sonoran Life Zones. Common communities found in the study area include: (1) Blackbrush - Galleta , on many of the canyon slopes and benches, (2) Shadscale - Galleta - Ephedra , common in many areas with south facing slopes and benches, (3) Pinyon - Juniper , found on mesa and rim tops throughout the study area, and (4) Salina Wild Rye - Galetta , on north or west facing slopes. Occasionally, junipers and other shrubs from the pinyon-juniper community are found on talus slopes and benches. Vegetation is usually sparse, but during years of good rainfall, plant production is greatly increased.

Temperatures range from 0 degrees to 40 degrees C throughout the year, and the average annual precipitation is generally less than 25 cm.

Procedures

Field work for the third phase of the study began in January 1983 and continued through September 1983. An additional 12 bighorn (8 mature ewes, 2 ewe lambs, 3 1/2 year-old ram, yearling ram) were captured and fitted with radio transmitters January 30-February 1, 1983. This brought the total of collared bighorn in the study area to 22 (Table 1). Bighorn were located with a Hughes 500 D jet helicopter and then hazed toward 8 foot by 100 foot tangle nets that were set in canyon and wash bottoms. Bighorn ran into the nets and became entangled, allowing biologists to restrain the animals without any drugs. Captured bighorn were fitted with radio-collars (Telonics Inc., Mesa, Arizona), bled by jugular puncture, and released. Collared sheep were monitored through 1983 by monthly fixed-wing telemetry flights with UDWR and ground locations made as often as possible. Locations were plotted on U.S.G.S. 15-minute topographic maps. Home range sizes were determined by connecting peripheral locations to form polygons (Mohr 1947) and then areas were calculated using a dot grid.

Habitat utilization was determined by recording slope aspect, topographic type, and vegetation type each time radio-collared bighorn and their associates were observed. The same procedure was followed to determine cattle habitat utilization. Habitat use of bighorn and cattle was compared by contingency analyses (Steel and Torrie 1980).

Forage utilization by desert bighorn sheep was determined by recording frequencies of use of different plant species at various feeding sites. Use of a culm of grass, leaf or stem of forbs, or leader of trees or shrubs constituted one instance of use (Lauer and Peek 1976). Instance of use was recorded for each sheep in the group being

observed in rotation for as long as the sheep could be observed feeding. Forage was recorded by plant species when possible or by forage class when species could not be determined. The same procedure was followed when observing cattle feeding behavior.

Seasonal diets of bighorn were compared by contingency analysis as were diets of bighorn and cattle (Steel and Torrie 1980).

Influence of recreation on bighorn has been difficult to assess because of relatively few observable encounters between humans and sheep. The influence has been evaluated in terms of sheep reaction with respect to the following variables each time the researcher observed an interaction between sheep and people:

1. Group classification; ewes-lambs, rams, or rams-ewes-lambs.
2. Group size; single animals, groups of 2-7, groups greater than 7 animals.
3. Distance to disturbance; close - 0 to 75 m, medium - 75 to 300 m, far - greater than 300 m.
4. Type of disturbance; hiker, vehicle, plane, boat.

The response of the sheep to the above disturbance variables was recorded as being:

1. Light - little to no reaction to disturbance, slight interruptions of behavior.
2. Moderate - significant interruptions in normal behavior or casual movement away from area.
3. Extreme - hurried flight away form disturbance.

Response of bighorn was compared by group composition, groups size, and distance to disturbance by contingency analysis (Steel and Torrie 1980).

Each month immediately after fixed-wing telemetry flights were made, one radio-collared bighorn was locted from the ground to determine

distance moved after being circled at relatively low elevations by a fixed-wing aircraft. Distance moved was measured on U.S.G.S. 15 minute topographic map and average distance moved was calculated.

Disease information was collected during capture and collaring operations. A federal veterinarian collected blood samples from 30 bighorn by jugular puncture, separated blood serum,and sent them to U.S. Department of Agriculture Veterinary Services laboratories in Salt Lake City, Utah, and Ames, Iowa, for analysis. Serum was checked to determine if sheep had been exposed to or infected by anaplasmosis (card agglutination test), brucellosis (plate agglutination test), blue tongue (compliment fixation test), contagious ecthyma (compliment fixation test), leptospirosis (plate agglutination test), and vesicular stomatitis (compliment fixation test). Bighorn were examined externally to determine if sheep were infected with sinusitis, scabies mites, or any other external diseases. Successful bighorn sheep hunters were also questioned to determine if their rams had any physical abnormalities.

RESULTS

Movements and Habitat Utilization

Movements

Movement patterns of desert bighorn in southeastern Utah have been monitored since February 1981 when 7 bighorn (5 rams, 2 ewes) were fitted with radio-collars. Seven bighorn (2 rams, 5 ewes) were collared in 1982, and 12 bighorn (2 rams, 10 ewes) were collared in 1983. One ram was killed by a mountain lion (Felis concolor) in 1981, another ram died of unknown causes shortly after it was collared in 1982, and 2 ram collars have malfunctioned, reducing the number of bighorn being monitored to 22 (Table 2).

Generalized patterns of home range, movements, and habitat utilization have been based on monthly fixed-wing telemetry flights as well as ground locations of bighorn since February 1981.

Home range areas for radio-collared bighorn in the BLM study area (Figures 2-24) are similar to those reported by Bates et al. (1975) in Utah and Leslie (1977) in Nevada. Average home range size of rams (94.47 km^2 , ranging from 41.12 km^2 to 195.0 km^2 , n = 6) is greater than average home range size of ewes (24.1 km^2 , ranging from 14.89 km^2 to 38.05 km^2 , n = 13).

Home range areas one ram (R85, 7 locations) and 4 ewes (E110, E120, E140, E390, all 8 locations) were not used in calculation of home range size because of relatively few relocations.

The extent of ewe movements throughout an annual cycle is more restriced than ram movements for the same period. Ewes do not show distinct migration routes nor several distinct seasonal ranges as has been recorded for Rocky Mountain sheep (Geist 1971); rather they move

frequently to different areas of their annual home range throughout the year with no easily recognizable pattern.

One trend that is apparent is consistent use of the same general area each year by ewes during lambing season. Two ewes (E115, E145) have been monitored during 3 lambing seasons and each year both ewes returned to the same specific area of their respective home ranges. Five ewes (E80, E150, E200, E345, E365) monitored through 2 lambing seasons also returned to the same areas of their home ranges each year. This suggests that ewes are using the same general area of their home ranges during the lambing season.

Two ewes (E345, E365) and their associates crossed Utah Highway 95 a minimum of 6 times during 1982. In 1983 these 2 ewes crossed the highway a minimum of 2 times. This indicates that current levels of vehicular traffic on Utah Highway 95 are not sufficient to prevent bighorn from crossing from one side of White Canyon to the other.

One ewe (E120) was captured and collared in January 1983 in Gypsum Canyon where she remained until mid-June 1983. In June E120 was located in the Needles District of Canyonlands National Park, 7 air miles to the northeast. E120 has remained inside Canyonlands National Park since June and has moved as far north as Salt Creek, 20 air miles from the capture site and 13 air miles inside the park.

Ram movements are more extensive than ewe movements and rams generally utilize more drainages as Bates et al. (1975) also found during telemetry studies the in same general area.

No distinct seasonal movements patterns are readily identifiable for rams with the exception of pre- and post- rut movements. Prior to the rut, rams are spatially segregated from ewes, but as the breeding

season approaches (mid-October), rams leave summer ranges and move to areas occupied by ewe groups.

Four rams (R65, R75, R135, R155) have been monitored through 2 breeding seasons. All 4 rams have returned to the same areas each year during the rut, and have spent a majority of the breeding season with the same group of ewes. This suggests that rams exhibit fidelity to breeding areas within the study area.

As rutting activity decreases, rams leave ewe groups and move to winter-spring ranges which may or may not be different from summer ranges. By mid-January, mature rams are generally not found with ewe groups, however, immature rams often remain with ewe groups throughout the year.

Home range areas for radio-collared desert bighorn and corresponding dates for each location are shown in Figures 2-24.

Habitat Utilization

Habitat use by bighorn within the BLM study area was evaluated in terms of 3 major variables. Aspect, topographic type, and vegetation type were recorded for 1914 bighorn since the project began in 1981.

All aspects were used by bighorn in the study area. Southeast (20.06%), southwest (16.88%), northwest (15.99%), and south (15.83%) facing slopes were selected most often by bighorn (Table 3). A breakdown for aspect use by bighorn for Red Canyon and White Canyon is listed in Tables 4 and 5.

The topographic types most often selected by bighorn within the study area (Table 3) were Chinle talus slopes (55.38%) and Moenkopi talus slopes (26.55%). There is a disparity in use of topographic types when Red and White Canyons are compared (Tables 4, 5). In Red Canyon

91.97% of bighorn observations were recorded on Chinle talus slopes and only 0.80% of bighorn observations were on Moenkopi talus slopes. In White Canyon 31.97% of bighorn observations were recorded on Chinle talus slopes and 43.19% were on Moenkopi talus slopes. This significant difference can be attributed to the lesser Chinle talus topographic type in White Canyon.

Major vegetation types selected in the study area (Table 3) were Pinyon-Juniper (41.00%) and Shadscale-Galleta-Ephedra (40.13) associations. Differences betweeen Red Canyon and White Canyon again occur due to lesser Chinle talus topographic type in White Canyon. In Red Canyon the Shadscale-Galleta-Ephedra (73.23%) vegetation type was most selected (Table 4) and in White Canyon the Pinyon-Juniper (66.32%) vegetation type was most selected (Table 5).

Forage Utilization

Forage selection by desert bighorn in southeastern Utah was monitored in all four calendar seasons (fall, October-December 1982; winter, January-March 1983; spring, April-June 1983; summer, July-September 1983) during phase 3 of the study.

During fall 1982, 83 bighorn were observed during feeding bouts and 2175 feeding instances were recorded. Browse plants (54.90%) were most often selected by sheep, but grasses (44.69%) were frequently selected (Table 6). Important diet components included: blackbrush, *Coleogyne ramosissima* (32.28%), galleta grass, *Hilaria jamesii* (26.35%), cliffrose, *Cowania mexicana* (19.17%), salina wild rye, *Elymus salinus* (9.79%), and cheat grass, *Bromus tectorum* (7.45%). A complete list of plant species selected by desert bighorn during fall 1982 is tabulated in Table 7.

During winter 1983, 88 bighorn were observed during feeding bouts and 2046 feeding instances were recorded. Browse plants (69.84%) were selected most often and although grasses (29.28%) were selected with considerable frequency, they were not as important as during fall 1982 (Table 8). Important diet components included: blackbrush (59.93%), galleta grass (15.60%), cheatgrass (11.05%), and cliffrose (4.06%). A complete list of plant species selected by desert bighorn during winter 1983 is tabulated in Table 9.

During spring 1983, 130 bighorn were observed during feeding bouts and 2206 feeding instances were recorded. Again, browse plants (67.64%) dominated the diet while grasses (28.89%) contributed approximately the same percentage to the diet as during winter 1983. Forbs (3.47%) were selected only rarely compared to browse and grass species (Table 10).

Important diet components included: cheatgrass (25.70%), blackbrush (25.15%), cliffrose (18.29%), shadscale, Atriplex confertifolia (13.19%), and Ephedra, Ephedra sp. (9.11%). A complete list of plant species selected by desert bighorn, spring 1983, is tabulated in Table 11.

During summer 1983, 109 bighorn were observed during feeding bouts and 2056 feeding instances were recorded. Browse plants (39.01%) were selected most frequently, however, grasses (30.25%) and forbs (30.74%) were selected nearly as frequently (Table 12). Important diet components included: galleta grass (27.63%), cliffrose (21.98%), Russian thistle, Salsola kali (18.29%), squaw bush, Rhus trilobata (7.49%), shadscale (4.77%), Mojave aster, Machaeranthera tortiofolia (4.09%), and blackbrush (3.31%). A complete list of plant species selected during summer 1983 is tabulated in Table 13.

Forage class was compared by calendar season in a 3x4 contingency table (Table 14) to determine statistically if forage class differs seasonally in bighorn diets. The Chi-square value was highly significant (Chi-square = 1863.58, df = 6) indicating that seasonal diets are, in fact, significantly different with respect to forage class selected by bighorn.

This seasonal variation in the relative importance various forage classes play in bighorn diets is readily apparent in Figure 25. Browse was most important in all seasons, however, importance was reduced in fall 1982 with increased use of grasses and reduced in summer 1983 with increased use of grasses and forbs.

Although percentage of forage classes in bighorn diets varied seasonally, there were specific diet components that were consistently

important in all seasons. Key plant species selected in all season included blackbrush, galleta grass, cliffrose, and cheatgrass. These four plants composed a majority of bighorn diets in all four seasons. In fall 1982, they were responsible for 82.25% of the diet, in winter 1983 for 90.64%, in spring 1983 for 71.11%, and in summer 1983 for 52.92% of the diet (see Tables 7,9,11,13 for seasonal totals of each species).

Comparison of previous years' diet analysis results with results of the current phase of the study (Table 15) suggest that importance of forage class also varies within seasons as well as between seasons. Bighorn diets on BLM administered lands in southeastern Utah are considerably variable, no doubt resulting from a variety of factors that affect the bighorn's environment through time.

Influence of Livestock

Competition between domestic livestock and desert bighorn sheep is a major concern to wildlife biologists and land managers as well as livestock operators. If competition is to occur, it will be in an area where potentially competing species are living sympatrically and necessary resources (e.g., food, water, space, cover) are limited. Currently there are three cattle allotments within the boundaries of the bighorn study area where potential for competition between cattle and bighorn exists (see King and Workman 1982 for description of allotment boundaries, stocking rates and grazing seasons).

Detailed investigations have only been conducted in the White Canyon allotment to determine niche overlap between bighorn and cattle. No radio-collared sheep were located in the Indian Creek allotment, and cattle were not grazed officially in the Red Canyon pasture of the Lake Canyon allotment during 1981-82 or 1982-83 grazing seasons. A few trespass cattle grazed in Red Canyon during both years, however, those animals' use of the area was sporadic and not easily monitored. Therefore, results and discussion of livestock (cattle) influence on bighorn is based on the White Canyon area only.

To determine if cattle and bighorn are potentially competing for resources in the White Canyon area, niche overlap with respect to topographic and forage use was analyzed during two grazing seasons (1981-82, 1982-83). The White Canyon allotment is presently managed under a year-round pasture rotation system. Cattle are moved into the White Canyon area to winter in late October or early November where they remain until late April or early May when they are moved to summer ranges. If competition is to occur, it will be during this period when

cattle and bighorn are in close proximity and potentially use similar topographic and forage types and exhibit any social intolerance.

Topographic Use

In the White Canyon area there are several topographic types available for use by bighorn and cattle (Figure 26). Chinle talus slope, Mossback-Shinarump mesa top, Moenkopi talus slope, Lower Cutler slope, and Cutler Valley floor are the five major topographic types (see SVIM report for detailed description of geology, vegetation, etc. of representative areas) in the area. To compare bighorn and cattle use of the various topographic types, a 2 x 5 contingency table (Table 16) was constructed. The Chi-square value was highly significant (Chi-square = 689.21, df = 4) suggesting that bighorn and cattle use the available habitat types differently during the grazing season. This is illustrated graphically (Figure 27) showing that cattle use only Cutler Valley floors (81.23%) and gentle Cutler talus slopes (18.77%), while bighorn predominantly select Moenkopi talus slopes (38.89%) and Chinle talus slopes (30.90%) and less commonly use Mossback-Shinarump mesa tops, Lower Cutler slopes and Cutler Valley floors.

It is evident from this analysis that bighorn tend to use higher, steeper slopes, while cattle use lower, gentler slopes and valley floors.

Forage Use

Cattle and bighorn diet selection was determined by observing feeding bouts of both species and recording plant species eaten during obervation periods throughout grazing seasons of 1981-82 and 1982-83.

During the two grazing seasons, 91 cattle were observed during feeding bouts and 2331 feeding instances were recorded. Grass plants

(56.03%) were most often selected by cattle, but browse plants (43.58%) also made up a significant portion of cattle diet (Table 17). Important diet components included: cheatgrass (31.49%), galleta grass (21.11%), blackbrush (14.84%), shadscale (13.73%), 4-wing saltbush, Atriplex canescens (6.44%), and broom snakeweed, Gutierrezia sorothrae (5.15%). A complete list of plant species selected by cattle during the grazing season is tabulated in Table 18.

During the two grazing seasons, 134 bighorn were observed in feeding bouts and 2306 feeding instances were recorded. Browse plants (91.11%) were highly selected over grasses (8.20%) and forbs (0.69%) by bighorn during the grazing seasons (Table 17). Important diet components included: blackbrush (73.29%), cliffrose (16.31%), cheatgrass (3.51%), and galleta grass (2.04%). A complete list of plants selected by bighorn during grazing seasons is tabulated in Table 18.

Cattle and bighorn diets were compared by using a 2 x 3 contingency table (Table 19) to determine if diet differed with respect to forage class. The Chi-square value (Chi square = 1214.2, df = 2) was extremely high, indicating that cattle and bighorn diets are different based on forage class during the grazing season. Figure 28 demonstrates graphically how diets differed between cattle and bighorn. Cattle used primarily grass and secondarily browse, while bighorn diet was dominated by browse, and grass was of little importance.

Although cattle were primarily grazers and bighorn were primarily browsers, there was considerable overlap in diet components between the two species. Cattle had 12 diet items, 10 of which were common to bighorn diets (83.34% shared). Bighorn had 14 diet items, 10 of which

were common to cattle diets (71.43% shared). To determine if individual diet components were of equal importance to both species, diets of cattle and bighorn were compared with a Percent Similarity Index (Whittaker 1975). The Percent Similarity Index value was calculated to be PSI = 0.2346. As the index value approaches 1, diets approach equity both in composition and proportion of components. The relatively low PSI value indicates relatively small dietary overlap between cattle and bighorn. Although there are several diet items common to both species, various diet items differ in relative importance to cattle and bighorn. For example, blackbrush was the most important component of the bighorn diet (73.29 %), while it ranked third in cattle diets (14.84%). Cheatgrass, the most important diet item of cattle (31.49%), ranked third for bighorn (3.51%). Cliffrose, second in bighorn diets (16.31%), was not found in cattle diets, and shadscale, fourth in the cattle diet (13.73%), was not found in the bighorn diet.

Social Intolerance Between Bighorn and Cattle

As in other areas, bighorn and cattle in the White Canyon area are spatially segregated. A major consideration was whether or not bighorn used the area differently when cattle were not on the range. In order to determine if bighorn used the area differently during the non-grazing season (May through October), a 2 x 5 contingency table (Table 20) was constructed comparing grazing season and non-grazing season bighorn use of topographic types. The Chi-square value was not significant (Chi-square = 5.62, df = 4), suggesting that bighorn did not use topographic types differently during the grazing and non-grazing seasons. This is easily seen in Figure 29.

Influence of Humans

Influence of Recreation

Recreational activities within the BLM desert bighorn sheep study area include hiking, backpacking, off-road vehicle touring, boating and fishing. These activities generally occur in the spring and fall when environmental conditions are relatively moderate compared to hot summers and cold winters. Because of the remotemess of the area, recreational levels at present are relatively low. However, the popularity of the area as a recreation site appears to be increasing yearly.

Major recreational activities that occur within the bighorn study area are the wilderness schools sponsored by a variety of organizations. These schools teach camping and survival skills to relatively large groups of people for extended periods of time. During 1983, 10 wilderness school groups (441 people) used BLM administered lands in or in close proximity to desert bighorn habitat for 111 days (Table 21). This number is up from 1982 and reflects the upward trend of this activity over the past several years (Table 22). Because wilderness school groups utilize bighorn habitats primarily during spring and fall months, there is potential for conflict between humans and bighorn during lambing and breeding seasons. Severe disturbance during these seasons may be detrimental to bighorn populations. River trips by private and commercial parties through Cataract Canyon also provide a major source of recreation in the area. These trips down the Colorado River take thousands of visitors through bighorn habitat every year. Many rafters are able to observe bighorn in the canyon as they travel from Moab to Hite.

Data collected since 1976 demonstrate the numbers of trips/year and

passengers/year is generally increasing (Table 23). A uncharacteristically sharp decline was noted in 1983. This drop was attributed to the extremely high spring runoff levels, tremendous amounts of debris in the river, and closure of Cataract Canyon for several days. These poor conditions early in the river running season caused the sharp decline.

A majority of trips taken in 1983 were from June through September (Table 24), reflecting the relatively late start of the season. The usually high number of trips in May and June may pose potential conflicts to bighorn during the lambing season, although a majority of lambs are born before June.

Most participants of river trips that have seen bighorn while floating through Cataract Canyon report that bighorn appear to be disturbed very little by boaters as they pass by. Many report boats being able to approach closely before bighorn move away. Others report that bighorn remain calm until boats land and people approach the bighorn on foot. This has been reported by Graham (1980) for desert bighorn along the Colorado River.

The researcher has observed 27 interactions between boats and bighorn. In 65.51% (19 of 29) of the instances bighorn showed little or no reaction (slight interruptions in behavior), in 20.69% (6 of 29) of the instances bighorn reacted moderately (significant interruptions in behavior or walk away from disturbance), and in 13.80% (4 of 27) of the instances bighorn reacted extremely (hurried flight) to the disturbance. Extreme responses were caused by boats passing within 50 m of bighorn (2 of 4 cases) or people getting out of a boat below the bighorn (2 of 4 cases--both cases people were approximately 300 m away from bighorn).

Moderate responses occurred when boats passed within an average of 241 m (ranging form 50-800 m). Light responses occurred when boats passed within an average of 308 m (ranging form 150-800 m).

The 1983 desert bighorn sheep hunt was held from September 17-October 16. Ten permits were issued over 3 hunting units. Five permits were issued in south San Juan unit, 2 permits in north San Juan unit, 2 permits in Potash unit (not within study area), and 1 permit (special high-bid permit) was valid on any hunting unit (see King and Workman 1982 for location of hunting units). Nine of 10 hunters were successful. Six sheep were killed in the south San Juan, 2 sheep were killed in the north San Juan, and 1 sheep was killed in the Potash unit. This is the most successful hunt since 1967 when 9 of 10 permits were validated.

Influence of Vehicles

Interactions between bighorn and vehicles were observed on 126 occasions. These data were analyzed statistically (3 x 3 contingency table) to determine how group size, group composition, distance to disturbance affected severity of response by bighorn to the disturbance (Table 25). Analysis indicated that bighorn response to vehicular disturbance was dependent on group composition (Chi-square = 38.73, df = 4), group size (Chi-square = 19.16, df = 4), and distance to disturbance (Chi-square = 76.69, df = 4). This suggests that groups of different composition respond differently to vehicular traffic. Ewe groups appear to be more tolerant of vehicular traffic and respond less severely than ram groups and mixed-sex groups.

As groups size increases, the severity of response to disturbance decreases. This suggests that larger groups are more tolerant of

vehicular traffic.

As distance to vehicular disturbance increases, the severity of response decreases. This suggests that as vehicular traffic approaches bighorn to close distances, bighorn are more severely harassed.

Influence of Hikers

Interactions between bighorn and hikers were observed in 119 occasions. These data were analyzed statistically (3 x 3 contingency table) to determine how group composition, group size, distance to disturbance affected severity of response by bighorn to the disturbance (Table 26). Analysis indicated that bighorn response to hiker disturbance was independent of group composition (Chi-square = 1.93, df = 4) and distance to disturbance (Chi-square = 5.17, df = 4) but was dependent on group size (Chi-square = 9.98, df = 4). As group size increased, the severity of response decreased. This suggests that larger groups of bighorn are more tolerant of hiker disturbance than small groups.

Influence of Aircraft

To determine how much fixed-wing radio-telemetry flights were casuing sheep to move, the researcher located at least 1 radio-collared bighorn was located the same day as the flight or early the next morning after the flight. A total of 42 relocations after telemetry flights were made and the distance between fixed-wing location and ground location was measured to the nearest 0.10 km (100 m). The average distance moved by bighorn following telemetry flights was 0.84 km (840 m) and distances ranged from 0.10 km (100 m) to 4.83 km (4830 m). This suggests telemetry flights do not cause bighorn to move great distances despite rather low flight evelations for relatively prolonged periods.

DISEASE INFORMATION

In conjunction with the 1983 UDWR desert bighorn transplant operation, January 1983, blood samples were collected by jugular puncture from 30 desert bighorn sheep (14 in the BLM study area, 16 in Canyonlands National Park). Serum was separated, collected and sent to USDA Veterinary Services laboratories in Salt Lake City, Utah, and Ames, Iowa to determine if titers for anaplasmosis, blue tongue, brucellosis, leptospirosis, contagious ecthyma, and vesicular stomatitis were present. Desert bighorn in Utah had not previously been checked for contagious ecthyma or vesicular stomatitis. In fall 1982, some unknown mouth disease with symptoms similar to those of blue tongue, contagious ecthyma, and vesicular stomatitis affected several sheep in the Blue Notch-Hidden Valley area (King and Workman 1982), so blood samples were checked for those diseases as well. Results are summarized in Table 27.

All samples were negative for anaplasmosis, brucellosis, leptospirosis, and vesicular stomatitis. However, 33% (10 of 30) of the samples were positive for blue tongue (4 of 14, 28.6%, from BLM study area; 6 of 16, 35.5%, from Canyonlands National Park). Blue tongue was discounted as the disease sheep were infected with because none of the sheep sampled in the Blue Notch-Hidden Valley area had titers for blue tongue.

The probable cause for the mouth problems Blue Notch-Hidden Valley bighorn experienced in 1982 was contagious ecthyma. Ninety-three percent (28 of 30) of the samples had positive titers (14 of 14, 100%, in the BLM study area; 14 of 16, 87.5%, in Canyonlands National Park) indicating previous exposure to or actual infection by the virus virtually throughout the BLM study area as well as throughout

Canyonlands National Park.

During phase 3 of the study, no external symptoms of any diseases were observed in the BLM study area. None of the bighorn in the Blue Notch-Hidden Valley area were observed with any of the symptoms they had exhibited the previous year. No cases of desert bighorn chronic sinusitis were observed in the study area.

Overall vigor of bighorn in the BLM study area appeared very good during 1983. Lamb production was very good in the study area with a ewe:lamb ratio of 100:72. This is the highest ratio since the study began. The ewe:lamb ratio in 1981 was 100:58.6 and 100:42.9 in 1982. No lamb mortality was detectable through September 1983, however, a few lambs were observed coughing in latter September. Results of the UDWR census in November will allow determination of lamb mortality since summer.

Successful hunters reported 1 of 9 rams harvested during the 1983 hunting season were infected with scabies mites. This was judged not to be severe enough to be of significance. Scabies infections in Utah appear to be inconsequential to bighorn populations at present.

DISCUSSION AND RECOMMENDATIONS

Since February 1981, radio-collared desert bighorn sheep have been studied on BLM administered lands in southeastern Utah. Movements, habitat utilization, influence of livestock, influence of mining, influence of recreation, and diseases have been monitored.

Movements and habitat utilization data suggest that desert bighorn in southeastern Utah utilize large tracts of land with steep, rugged slopes. It is important that this be realized when developing management plans for the area so large acreages can be maintained for bighorn.

Rams exhibited fidelity to breeding areas and ewes exhibited fidelity to lambing areas from year to year. These facts also have important management ramifications. Precautions should be taken to prevent or minimize disturbances to those areas used by rams and ewes especially during breeding and lambing seasons so bighorn will not be forced to leave "traditional" areas and possibly move into lower quality areas. Cooperation of mining companies, mineral exploration companies, recreationists and livestock operators in avoiding these areas during critical periods should be sought.

Forage utilization data indicated that bighorn diets in southeastern Utah vary form year to year and season to season. Browse was the most important diet item in all seasons, with grass being important at certain times of the year. Key diet items for bighorn included blackbrush, galleta grass, cliffrose, and cheatgrass.

Comparison of diets of cattle and bighorn showed considerable overlap in forage taxa, but proportions of selected diet items differed significantly. From these data we conclude that diets of cattle and

bighorn do not overlap significantly at this point in time. This does not rule out potential for increased competition in areas where cattle stocking rates or bighorn numbers are excessive and bighorn and cattle are confined to use the same topographic types.

This situation may be possible in southeastern Utah if livestock operators are permitted to use mesa tops and higher talus slopes not currently used by cattle. For example, during 1983 the livestock operator in White Canyon chained approximately 600 acres of a state school section on Fry Mesa. Although no collared bighorn utilized that specific area, they did use areas of the mesa top within 1 mile of the chaining. This use of mesa tops by cattle should be closely monitored.

Many examples of social intolerance of bighorn to domestic livestock are cited in the scientific literature. Most are based on the circumstantial evidence of bighorn and cattle using different areas when on the same range (Barmore 1962, Follows 1969, Hudson et al. 1975, Dean 1977, McQuivey 1978, Goodson 1982). However, these studies do not document any mechanisms that cause the separation. A few are based on actual vacation or restriction of ranges by bighorn when livestock are introduced into the area (Wilson 1968, Irvine 1969, Dean and Spillet 1976, Dean 1977). Even more rare are the instances of range expansion by bighorn when livestock are removed from an area, however, Bates (1982) did observe range expansion of bighorn when cattle grazing was eliminated in Canyonlands National Park, Utah.

Because actual mechanisms that cause bighorn and cattle to separate spatially are difficult to observe and discover, we often assume that separation is based on social intolerance rather than preference or mechanical limitations of the species involved. However, the evidence

suggesting that bighorn and livestock are mutually intolerant is not overwhelming.

Human influence in the area is currently at a relatively low level. However, the potential for increased human intrusion into the area is high. The area has great recreational potential and some potential for mining under proper conditions. Mining in the area is presently non-existent because uranium ore prices are so low. However, should prices rise to a level where mining is economically feasible, activity may increase in the area.

Vehicular traffic in the study area has varying effects on sheep behavior depending on group composition, group size, and distance to disturbance. Severity of bighorn response increases as group sizes become smaller and as vehicles approach closer to the sheep. Some potentially severe disturbances may be avoided if the number of roads is maintained at its current level and people are encouraged to use existing roads only.

Severity of response to hiker disturbance was only dependent on group size. As group size decreased, the reaction of sheep was more severe. Hikers in bighorn habitats should be encouraged not to approach solitary sheep or small groups of sheep, especially during critical times such as lambing and breeding seasons. This may have particular significance during lambing season when parturient ewes seek isolation from other ewes.

In order to collect as much information as possible during telemetry flights (e.g. group size, group composition, ewe:lamb ratio, etc.), the plane circles at relatively low elevations for several minutes to ensure as many sheep as possible are observed. Some concern

has arisen that such a procedure may cause bighorn to leave the areas where they are harassed by the low flying plane. However, results indicate that bighorn harassed by telemetry flights are only moving an average of 0.84 km (approximately 1/2 mile) after telemetry flights. This would indicate that periodic low elevation telemetry flights in a fixed-wing aircraft do not cause sheep to abandon an area. Caution must be taken not to extrapolate these results to helicopter flights. If helicopter flights consist of several passes over an area, they may not have too much effect. However, if helicopters hover above bighorn at low elevations, the response of sheep may be severe enough to make them leave the area (King and Workman 1982).

Bighorn sheep in the study area appear to be relatively healthy at the present timme. Despite the occurrence of positive titers for blue tongue and contagious ecthyma in the population, bighorn do not appear to be suffering ill effects from either disease. The clinical cases of contagious ecthyma observed in the Blue Notch area are the first to be documented in Utah. Although no lasting detrimental effects were observed in these cases, the disease is a potential problem if severe enough at critical times. If the disease occurs during the breeding or lambing seasons, lamb production may be reduced. However, the cases observed in Blue Notch Canyon occurred in September and October, just prior to the rut, and 7 of 8 affected ewes had lambs the following spring so they were not affected too severely.

One concern regarding bighorn population vigor in southeastern Utah is lamb mortality. Ewe:lamb ratios show marked declines from summer through fall. The summer ewe:lamb ratio for 1983 was 100 ewes:72 lambs. By November the ewe:lamb ratio had dropped to 100:45 lambs (Bates 1983,

personal communication). Several lambs were observed coughing severely in late September which suggests respiratory problems, perhaps pneumonia, common to other bighorn populations. An investigation into causes of lamb mortality should be encouraged.

EXPERIENCED AND ANTICIPATED PROBLEMS

During phase 3 of the study relatively few problems were experienced. During winter months, harsh weather prevented the researcher from doing field work on several occasions. Snow or rain on many roads precludes their use, and areas where sheep are located are not accessible.

Another problem was the lack of communication facilities at Fry Canyon. There is no longer a telephone at the store, which made it necessary to travel to Blanding whenever it was necessary to talk to BLM, UDWR, or USU personnel. A radio mounted in the truck would be very advantageous to the project not only for convenience but for safety as well.

There were no problems with any of the radio-collars during phase 3 of the project. Presently there are 22 functioning collars on bighorn sheep. During capture and collaring operations in 1983, 2 sheep were captured that had collars that no longer functioned. Both were replaced with new collars to maintain continuity in data collection.

No major problems are anticipated in the future. All agencies involved with the project have cooperated to make the fieldwork flow as smoothly as possible.

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APPENDICES

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TABLES

Table 1. Sex, age, and primary location of radio-collared bighorn on BLM administered lands in southeastern Utah.

No.	Sex	Age	Year collared	General location
R65[1]	M	4 1/2	1981	Jacobs Chair
R75	M	4 1/2	1981	Wilson Canyon
R85[2]	M	2 1/2	1981	Dark Canyon
R135[3]	M	3 1/2	1981	Wingate Mesa
R155	M	3 1/2	1981	Sheep Canyon
R316[4]	M	7 1/2	1982	Wilson Canyon
R355[5]	M	3 1/2	1982	Short Canyon
R130	M	1 1/2	1983	Short Canyon
R355[6]	M	4 1/2	1983	Wingate Mesa
E115	F	Mature	1981	Mahon Canyon
E145	F	Mature	1981	Blue Notch Canyon
E80	F	Mature	1982	Sheep Canyon
E150	F	Mature	1982	Blue Canyon
E200	F	Mature	1982	Short Canyon
E345	F	Mature	1982	Found Mesa
E365	F	Mature	1982	Found Mesa
E110	F	Mature	1983	Gypsum Canyon
E120	F	Mature	1983	Canyonlands National Park
E140	F	Mature	1983	Cataract Canyon
E170	F	Mature	1983	Piute Canyon
E180	F	Lamb	1983	Sheep Canyon
E335	F	Mature	1983	Sheep Canyon
E350	F	Mature	1983	Blue Canyon
E370	F	Mature	1983	Hidden Valley
E380	F	Mature	1983	Sheep Canyon
E390	F	Lamb	1983	Gypsum Canyon

[1] Ram 65 was recollared with collar #385 in 1983
[2] Ram 85 was killed by a cougar September 1981
[3] Ram 135's collar is no longer working
[4] Ram 316's collar is no longer working
[5] Ram 355 died approximately six weeks after being collared in 1982
[6] Ram 355 was collared with a refurbished collar #355

Table 2. Estimated home range size of radio collared bighorn sheep in southeastern Utah.

Sex	Age	Number	Number relocations	Relocation period	Home range size (km)
Rams	1 1/2	R130	39	Feb.83-Oct.83	41.12
	2 1/2	R85*	7	Feb.81-Sept.81	--
	3 1/2	R135	36	Feb.81-July83	195.00
	3 1/2	R155	29	Feb.81-Oct.83	42.58
	4 1/2	R65	60	Feb.81-Oct.83	121.24
	4 1/2	R75	54	Feb.81-Oct.83	84.01
	4 1/2	R355	24	Feb.83-Oct.83	82.88
				Average	94.47
Ewes	1 1/2	E180	13	Feb.83-Oct.83	33.02
	1 1/2	E390*	8	Feb.83-Oct.83	--
	Mature	E080	25	Feb.82-Oct.83	24.60
	Mature	E115	49	Feb.81-Oct.83	15.80
	Mature	E145	65	Feb.81-Oct.83	34.48
	Mature	E150	33	Feb.82-Oct.83	14.89
	Mature	E200	52	Feb.82-Oct.83	38.05
	Mature	E345	60	Feb.82-Oct.83	29.46
	Mature	E365	65	Feb.82-Oct.83	29.46
	Mature	E335	11	Feb.83-Oct.83	21.02
	Mature	E380	13	Feb.83-Oct.83	16.35
	Mature	E350	20	Feb.83-Oct.83	22.34
	Mature	E370	23	Feb.83-Oct.83	16.51
	Mature	E170	19	Feb.83-Oct.83	17.32
	Mature	E110*	8	Feb.83-Oct.83	--
	Mature	E120*	8	Feb.83-Oct.83	--
	Mature	E140*	8	Feb.83-Oct.83	--
				Average	24.10

*Not used in calculation of home range size because of few relocations

Table 3. Habitat utilization by desert bighorn sheep within the BLM study area (Red and White Canyons combined), 1981-83.

Aspect	Number of Observations	Percent total
East	182	9.51
West	123	6.43
South	303	15.83
North	108	5.64
Southeast	384	20.06
Southwest	323	16.88
Northeast	185	9.67
Northwest	306	15.99
Total	1914	100.00

Topographic type	Number of Observations	Percent total
Mossback-Shinarump mesa top	132	6.90
Wingate mesa top	5	0.26
Chinle talus	1060	55.38
Moenkopi talus	510	26.65
Cutler talus	86	4.49
Valley floor	121	6.32
Total	1914	100.00

Table 3. Habitat utilization . . . cont.

Vegetation type	Number of observations	Percent total
Blackbrush, galleta	290	15.15
Shadscale, galleta, ephedra	768	40.13
Pinyon, juniper	785	41.00
Salina wild rye, galleta	71	3.71
Total	1914	100.00

Table 4. Habitat utilization by desert bighorn sheep in the Red Canyon area of southeastern Utah, 1981-83.

Aspect	Number of observations	Percent total
East	104	13.92
West	54	7.23
South	170	22.76
North	21	2.81
Southeast	203	27.18
Southwest	58	7.76
Northeast	38	5.09
Northwest	99	13.25
Total	747	100.00

Topographic type	Number of observations	Percent total
Mossback-Shinarump mesa top	0	0.00
Wingate mesa top	5	0.67
Chinle talus	687	91.97
Moenkopi talus	6	0.80
Cutler talus	0	0.00
Valley floor	49	6.56
Total	747	100.00

Table 4. Habitat utilization . . . cont.

Vegetation type	Number of observations	Percent total
Blackbrush, galleta	118	15.80
Shadscale, galleta, ephedra	547	73.23
Pinyon, juniper	11	1.47
Salina wild rye, galleta	71	9.50
Total	747	100.00

Table 5. Habitat utilization by desert bighorn sheep in the White Canyon area of southeastern Utah, 1981-83.

Aspect	Number of observations	Percent total
East	78	6.68
West	69	5.91
South	133	11.40
North	87	7.46
Southeast	181	15.51
Southwest	265	22.71
Northeast	147	12.60
Northwest	207	17.48
Total	1167	100.00

Topographic type	Number of observations	Percent total
Mossback-Shinarump mesa top	132	11.31
Wingate mesa top	0	0.00
Chinle talus	373	31.97
Moenkopi talus	504	43.19
Cutler talus	86	7.37
Valley floor	72	6.17
Total	1167	100.00

Table 5. Habitat utilization . . . cont.

Vegetation type	Number of observations	Percent total
Blackbrush, galleta	172	14.74
Shadscale, galleta, ephedra	221	18.94
Pinyon, juniper	774	66.32
Salina wild rye, galleta	0	0.00
Total	1167	100.00

Table 6. Diet composition of desert bighorn by forage class in southeastern Utah, October-December 1982 (direct observation of 2175 feeding instances by 83 bighorn).

Forage class	No. feeding instances	Percent total
Grass	972	44.69
Browse	1194	54.90
Forbs	9	0.41
Total	2175	100.00

Table 7. Plant species selected by desert bighorn in southeastern Utah, October-December 1982 (direct observation of 2175 feeding instances by 83 bighorn).

Plant species	No. feeding instances	Percent total
Blackbrush	702	32.28
Galleta grass	573	26.35
Cliffrose	417	19.17
Salina wild rye	213	9.79
Cheat grass	162	7.45
Squawbush	30	1.38
Indian rice grass	24	1.10
Snakeweed	15	0.69
Ephedra	9	0.41
Shadscale	9	0.41
Rabbitbrush	9	0.41
Princes plume	3	0.41
Desert trumpet	3	1.14
Unidentified forbs	3	0.14
Unidentified grass	0	0.00
Unidentified browse	3	0.14
Total	2175	100.00

Table 8. Diet composition of desert bighorn by forage class in southeastern Utah, January-March 1983 (direct observation of 2046 feeding instances by 88 bighorn).

Forage class	No. feeding instances	Percent total
Grass	599	29.28
Browse	1429	69.84
Forbs	18	0.88
Total	2046	100.00

Table 9. Plant species selected by desert bighorn in southeastern Utah, January-March 1983 (direct observation of 2046 feeding instances by 88 bighorn).

Plant species	No. feeding instances	Percent total
Blackbrush	1279	59.93
Galleta grass	333	15.60
Cheat grass	226	11.05
Cliffrose	83	4.06
Shadscale	52	2.54
Salina wild rye	37	1.81
Bud sagebrush	10	0.49
Princes plume	7	0.34
Indian rice grass	3	0.15
Rabbitbrush	3	0.15
Ephedra	2	0.10
Mojave aster	2	0.10
Unidentified forbs	9	0.44
Unidentified grass	0	0.00
Unidentified browse	0	0.00
Total	2046	100.00

Table 10. Diet composition of desert bighorn by forage class in southeastern Utah, April-June 1983 (direct observation of 2206 feeding instances by 130 bighorn).

Forage class	No. feeding instances	Percent total
Grass	641	28.89
Browse	1495	67.64
Forbs	78	3.47
Total	2206	100.00

Table 11. Plant species selected by desert bighorn in southeastern Utah, April-June 1983 (direct observations of 2206 feeding instances by 130 bighorn).

Plant species	No. feeding instances	Percent total
Cheatgrass	567	25.70
Blackbrush	555	25.15
Cliffrose	404	18.29
Shadscale	292	13.19
Ephedra	201	9.11
Galleta grass	44	1.97
Desert trumpet	39	1.77
Bud sagebrush	26	1.16
Princes plume	20	0.88
Indian rice grass	9	0.41
Squawbush	9	0.41
Single leaf ash	8	0.34
Salina wild rye	3	0.14
Globe mallow	2	0.07
Unidentified forbs	17	0.75
Unidentified grass	15	0.68
Unidentified browse	0	0.00
Total	2206	100.00

Table 12. Diet composition of desert bighorn by forage class in southeastern Utah, July-September 1983 (direct observation of 2056 feeding instances by 109 bighorn).

Forage class	No. feeding instances	Percent total
Grass	622	30.25
Browse	802	39.01
Forbs	632	30.74
Total	2056	100.00

Table 13. Plant species selected by desert bighorn in southeastern Utah, July-September 1983 (direct observation of 2056 feeding instances by 109 bighorn).

Plant species	No. feeding instances	Percent total
Galleta grass	568	27.63
Cliffrose	452	21.98
Russian thistle	376	18.29
Squawbush	154	7.49
Shadscale	98	4.77
Mojave aster	84	4.09
Blackbrush	68	3.31
Princes plume	54	2.63
Desert trumpet	30	1.46
Indian rice grass	24	1.17
Ephedra	20	0.97
Serviceberry	8	0.39
Snakeweed	2	0.10
Unidentified forbs	88	4.28
Unidentified grass	30	1.46
Unidentified browse	0	0.00
Total	2056	100.00

Table 14. Contingency table comparing bighorn diets by forage class and calendar season (fall, October-December 1982; winter, January-March 1983; spring, April-June 1983; summer, July-September 1983). Numbers in parentheses are expected values.

Forage class	Season				
	Fall	Winter	Spring	Summer	Total
Grass	972 (725.94)	599 (682.88)	641 (738.96)	622 (686.22)	2834
Browse	1194 (1260.28)	1429 (1185.53)	1495 (1282.87)	802 (1191.32)	4920
Forbs	9 (188.78)	18 (177.59)	78 (192.17)	632 (178.46)	737
Total	2175	2046	2214	2056	8491

Chi-square = 1863.579*
df = 6

Table 15. Percentage of forage class selected in each season by desert bighorn throughout entire study.

Season	Year		
	1981	1982	1983
Winter			
Grass	--	--	29.28
Browse	--	--	69.84
Forbs	--	--	0.88
Spring			
Grass	--	--	28.89
Browse	--	--	67.64
Forbs	--	--	3.47
			100.00
Summer			
Grass	15.80	45.58	30.25
Browse	78.50	52.91	39.00
Forbs	5.70	1.51	30.75
	100.00	100.00	100.00
Fall			
Grass	27.91	44.69	--
Browse	70.29	54.90	--
Forbs	1.80	0.41	--
	100.00	100.00	

Table 16. Contingency table comparing number of locations of cattle and bighorn in topographic types during the grazing season (November-April 1981-82, 1982-83) in the White canyon area in southeastern Utah. Numbers in parentheses are expected values.

	Topographic type					
	Mossback-Shinarump mesa top	Chinle talus	Moenkopi talus	Cutler talus	Cutler valley floor	Total
Desert bighorn	33 (10.49)	89 (28.29)	112 (35.60)	29 (46.09)	25 (167.52)	288
Cattle	0 (22.51)	0 (60.71)	0 (76.40)	116 (98.91)	502 (359.48)	618
Total	33	89	112	145	527	906

Chi-square = 689.21*
df = 4

Table 17. Diet composition of cattle and desert bighorn by forage class during grazing season, November-April 1981-82, 1982-83, in the White Canyon area (direct observation of 2331 feeding instances by 91 cattle, 2306 feeding instances by 134 bighorn).

	No. feeding instances	Percent total
Cattle		
Grass	1306	56.03
Browse	1016	43.58
Forbs	9	0.39
Total	2331	100.00
Desert bighorn		
Grass	189	8.20
Browse	2101	91.11
Forbs	16	0.69
Total	2306	100.00

Table 18. Plant species selected by cattle and desert bighorn during grazing season, November-April 1981-82, 1982-83, in the White Canyon area (direct observation of 2331 feeding instances by 91 cattle, 2306 feeding instances by 134 bighorn).

Plant species	Bighorn		Cattle	
	No. feeding instances	Percent total	No. feeding instances	Percent total
Blackbrush	1690	73.29	346	14.84
Cliffrose	376	16.31	0	0.00
Cheatgrass	81	3.51	734	31.49
Galleta grass	47	2.04	492	21.11
Indian rice grass	40	1.73	66	2.83
Squawbush	18	0.78	0	0.00
Salina wild rye	15	0.65	0	0.00
Ephedra	7	0.30	74	3.17
Princes plume	7	0.30	0	0.00
Snakeweed	4	0.17	120	5.15
Juniper	3	0.13	2	0.09
Rabbitbrush	3	0.13	4	0.17
Shadscale	0	0.00	320	13.73
4-wing saltbush	0	0.00	150	6.44
Unidentified forbs	9	0.39	9	0.39
Unidentified grass	6	0.26	14	0.60
Unidentified browse	0	0.00	0	0.00
Total	2306	100.00	2331	100.00

Table 19. Contingency table comparing cattle and bighorn diets by forage class during grazing season (November-April 1981-82, 1982-83) in the White Canyon area. Numbers in parentheses are expected values.

	Forage class			
	Grass	Browse	Forbs	Total
Cattle	1306 (751.5)	1016 (1566.9)	9 (12.6)	2331
Desert bighorn	189 (743.5)	2101 (1550.1)	16 (12.4)	2306
Total	1495	3117	25	4637

Chi-square = 1214.2*
df = 2

Table 20. Contingency table comparing number of locations of bighorn in various topographic types during the grazing season (November-April 1981-82, 1982-83) and the non-grazing season (May-October 1982, 1983) in the White Canyon area. Numbers in parentheses are expected values.

Season	Topographic type: Mossback-Shinarump mesa top	Chinle talus	Moenkopi talus	Cutler talus	Cutler valley floor	Total
Grazing season	33 (29.84)	89 (97.29)	112 (117.58)	29 (23.58)	25 (19.70)	288
Non-grazing season	67 (70.16)	237 (228.71)	282 (276.42)	50 (55.42)	41 (46.30)	677
Total	100	326	394	79	66	965

Chi-square = 5.62
df = 4

Table 21. Wilderness school use of BLM lands within the desert bighorn study area, 1983.

Group name	Dates	Number of people	Areas
Colorado Outward Bound School (COBS)	1/14-18	24	Beef Basin, House Park Butte, Butler Wash
COBS	2/15-19	24	Indian Creek
	2/25-28	24	Indian Creek
National Outdoor Leadership School (NOLS)	2/9-13	16	Gypsum Canyon, Imperial Valley, Sweet Alice Canyon, Ruin Canyon
	2/10-12	15	House Park Butte
	3/16-29	13	Butler Wash, House Park Butte, Sweet Alice Canyon, Ruin Canyon, Fable
Valley,			
			Young's Canyon, Dark Canyon, Lost Canyon, Fort Knocker Canyon, White Canyon
COBS	4/8-10	24	Indian Creek
COBS	5/4-6	29	Indian Creek
	5/8-9	31	Home Springs, Fable Valley, Young's Canyon
	5/10-17	15	Dark Canyon, Ruin Canyon
	5/18-19	31	Sweet Alice Canyon, Beef Basin, Butler Wash

Table 21. Wilderness school . . . cont.

Group name	Dates	Number of people	Areas
COBS	10/10	27	Beef Basin
	10/11-12	36	Beef Basin, Calf Canyon, Sweet Alice Canyon, Ruin Canyon Fable Valley
	10/13-20	18	Young's Canyon, Dark Canyon
	10/21	36	Sweet Alice Canyon
Enviros	10/17-23	9	Calf Canyon, Sweet Alice Canyon, Fable Valley
NOLS	10/25-11/4	15	Beef Basin, Ruin Canyon, Trail
Canyon,			Dark Canyon, Bears Ears, Woodenshoe Canyon
	10/25-11/5	15	House Park Butte, Gypsum Canyon, Fable Valley, Young's Canyon, Dark Canyon, Lost Canyon, White Canyon, Fortknocker Canyon
NOLS	11/18-25	20	Beef Basin, Ruin Canyon, Sweet Alice Canyon, Fable Valley
	11/19-25	19	Gypsum Canyon, Fable Valley, Ruin Canyon, Sweet Alice Canyon, Beef Basin
Total	111	441	

Table 22. Number of people and number of days use of BLM lands by wilderness schools, 1978-1983.

Year	Number of people (P)	Number of days (D)	User days (P x D)
1978	290	43	12470
1979	162	39	6318
1980	245	87	21315
1981	278	87	24186
1982	281	97	27257
1983	441	111	48951

Table 23. Total private and commercial boat trips and passengers through Cataract Canyon (1976-1983). Data from Canyonlands National Park records, Moab, Utah.

Year	Number of trips	Percent increase	Number of passengers	Percent increase
1976	279	--	4864	--
1977	300	8	4809	-1
1978	325	8	5575	16
1979	344	6	5728	3
1980	380	10	6115	7
1981	333	-12	5126	-16
1982	353	6	4949	-3
1983*	262	-25	3439	-31

*1983 figures based on January-September data

Table 24. Total private and commercial boat trips and passengers through Cataract Canyon; monthly distribution January-September 1982, 1983.

Month	1982 Number trips	1982 Number passengers	1983 Number trips	1983 Number passengers
January-March	5	53	0	0
April 1-14	3	24	6	66
April 15-30	5	56	3	23
May	49	631	26	347
June	92	1395	57	817
July	103	1465	55	758
August	72	992	73	968
September	25	333	42	460
Total	353	4949	262	3439

Table 25. Contingency tables comparing group composition, group size, distance to disturbance and severity of response for vehicle disturbance (1982-83). Numbers in parentheses are expected values.

Group composition	Severity of response			
	Light	Moderate	Extreme	Total
Rams-ewes-lambs	4 (10.54)	11 (3.43)	1 (2.03)	16
Ewes-lambs	73 (61.92)	8 (20.14)	13 (11.94)	94
Rams	6 (10.54)	8 (3.43)	2 (2.03)	16
Total	83	27	16	126
Chi square = 38.73*, df = 4				
Group size				
1	5 (3.95)	1 (1.29)	0 (0.76)	6
2-7	10 (19.76)	13 (6.43)	7 (3.81)	30
7+	68 (59.29)	13 (19.29)	9 (11.43)	90
Total	83	27	16	126
Chi square = 19.16*, df = 4				
Distance to disturbance				
0-75 m	1 (9.22)	5 (3.00)	8 (1.78)	14
76-300 m	6 (17.13)	16 (5.57)	4 (3.30)	26
300+	76 (56.65)	6 (18.43)	4 (10.92)	86
Total	83	27	16	126
Chi square = 76.69*, df = 4				

Table 26. Contingency tables comparing group composition, group size, distance to disturbance and severity of bighorn response for hiker disturbance (1982-83). Numbers in parentheses are expected values.

Group composition	Severity of response			
	Light	Moderate	Extreme	Total
Rams-ewes-lambs	7 (5.45)	29 (27.76)	23 (25.78)	59
Ewes-lambs	2 (2.68)	14 (13.65)	13 (12.67)	29
Rams	2 (2.77)	13 (14.12)	16 (13.11)	30
Total	11	56	52	119
Chi square = 1.93(NS), df=4				
Group size				
1	0 (1.20)	3 (6.12)	10 (5.69)	13
2-7	5 (6.01)	34 (30.59)	26 (28.40)	65
7+	6 (3.42)	19 (17.41)	12 (16.17)	37
Total	11	56	52	119
Chi square = 9.98*, df = 4				
Distance to disturbance				
0-75 m	3 (4.16)	25 (21.18)	17 (19.66)	45
76-300 m	7 (5.82)	26 (29.65)	30 (27.53)	63
300 m+	1 (1.02)	5 (5.18)	5 (4.81)	11
Total	11	56	52	119
Chi square = 5.17(NS), df=4				

Table 27. Results of serological analyses of blood samples collected from 30 desert bighorn in Utah, January 1983.

Sample	Sex	Location	Anaplasmosis	Brucellosis	Leptospirosis	Blue Tongue	Contagious Ecthyma	Vesicular Stomatitis
1	F	Canyonlands National Park	-	-	-	-	+	-
2	F	Canyonlands National Park	-	-	-	-	+	-
3	F	Canyonlands National Park	-	-	-	-	+	-
4	F	Canyonlands National Park	-	-	-	+	+	-
5	F	Canyonlands National Park	-	-	-	-	+	-
6	F	Canyonlands National Park	-	-	-	-	+	-
7	F	Canyonlands National Park	-	-	-	+	+	-
8	F	Canyonlands National Park	-	-	-	-	+	-
9	M	Canyonlands National Park	-	-	-	-	+	-
10	M	Canyonlands National Park	-	-	-	-	+	-
11	M	Canyonlands National Park	-	-	-	+	+	-
12	M	Canyonlands National Park	-	-	-	+	-	-
13	F	Canyonlands National Park	-	-	-	-	-	-
14	F	Canyonlands National Park	-	-	-	+	+	-
15	F	Canyonlands National Park	-	-	-	+	+	-
16	F	Canyonlands National Park	-	-	-	-	+	-
17	F	Gypsum Canyon	-	-	-	-	+	-
18	F	Gypsum Canyon	-	-	-	+	+	-
19	F	Gypsum Canyon	-	-	-	-	+	-
20	F	Gypsum Canyon	-	-	-	+	+	-
21	F	Sheep Canyon	-	-	-	+	+	-
22	F	Sheep Canyon	-	-	-	-	+	-
23	F	Sheep Canyon	-	-	-	-	+	-
24	M	Sheep Canyon	-	-	-	-	+	-
25	F	Piute Canyon	-	-	-	+	+	-
26	F	Low Canyon	-	-	-	-	+	-
27	M	Hidden Valley	-	-	-	-	+	-
28	M	Hidden Valley	-	-	-	-	+	-
29	F	Hidden Valley	-	-	-	-	+	-
30	M	White Canyon	-	-	-	-	+	-
Total			0	0	0	10 33.33%	28 93.33%	0

(+) positive titer
(-) negative titer

FIGURES

Figure 1. BLM desert bighorn sheep study area.

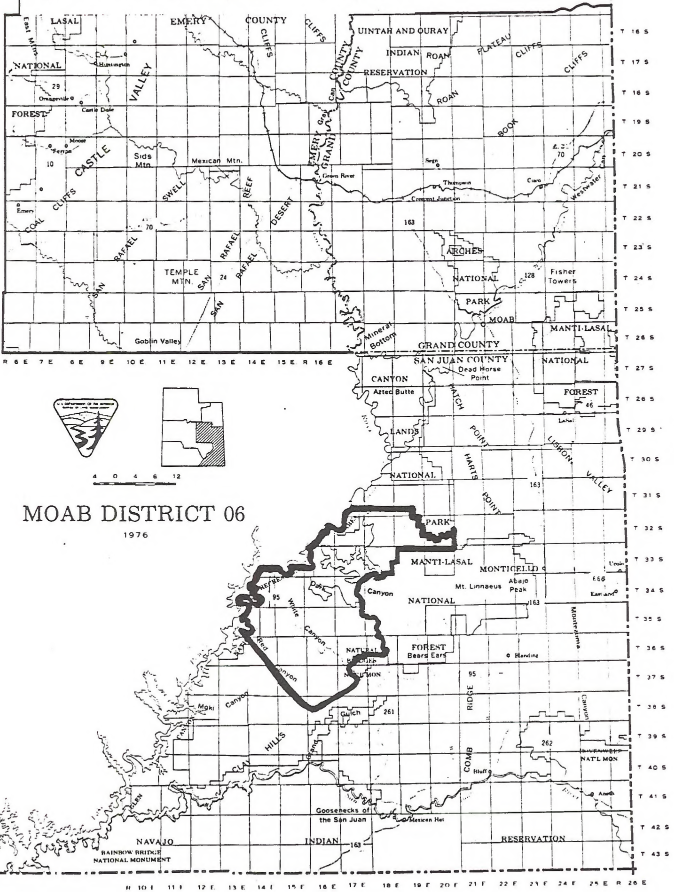
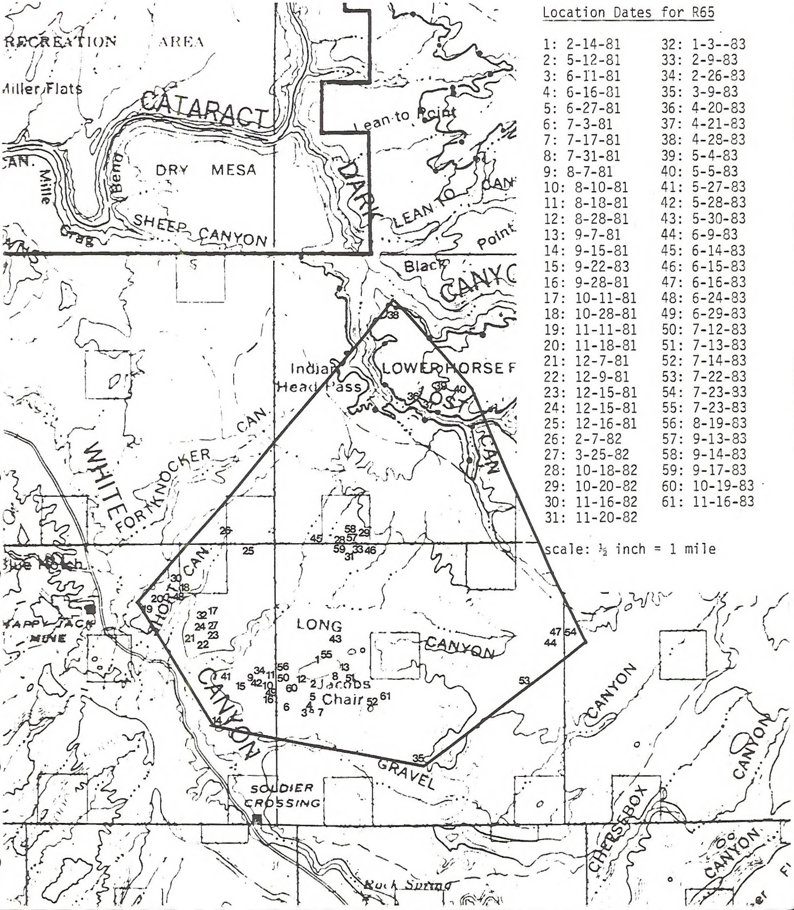


Figure 2. Home range area, individual locations and corresponding location dates for ram R65, 1981-1983.



Location Dates for R65

1: 2-14-81	32: 1-3--83
2: 5-12-81	33: 2-9-83
3: 6-11-81	34: 2-26-83
4: 6-16-81	35: 3-9-83
5: 6-27-81	36: 4-20-83
6: 7-3-81	37: 4-21-83
7: 7-17-81	38: 4-28-83
8: 7-31-81	39: 5-4-83
9: 8-7-81	40: 5-5-83
10: 8-10-81	41: 5-27-83
11: 8-18-81	42: 5-28-83
12: 8-28-81	43: 5-30-83
13: 9-7-81	44: 6-9-83
14: 9-15-81	45: 6-14-83
15: 9-22-83	46: 6-15-83
16: 9-28-81	47: 6-16-83
17: 10-11-81	48: 6-24-83
18: 10-28-81	49: 6-29-83
19: 11-11-81	50: 7-12-83
20: 11-18-81	51: 7-13-83
21: 12-7-81	52: 7-14-83
22: 12-9-81	53: 7-22-83
23: 12-15-81	54: 7-23-83
24: 12-15-81	55: 7-23-83
25: 12-16-81	56: 8-19-83
26: 2-7-82	57: 9-13-83
27: 3-25-82	58: 9-14-83
28: 10-18-82	59: 9-17-83
29: 10-20-82	60: 10-19-83
30: 11-16-82	61: 11-16-83
31: 11-20-82	

scale: ½ inch = 1 mile

Figure 3. Home range area, individual locations and corresponding location dates for ram R75, 1981-1983.

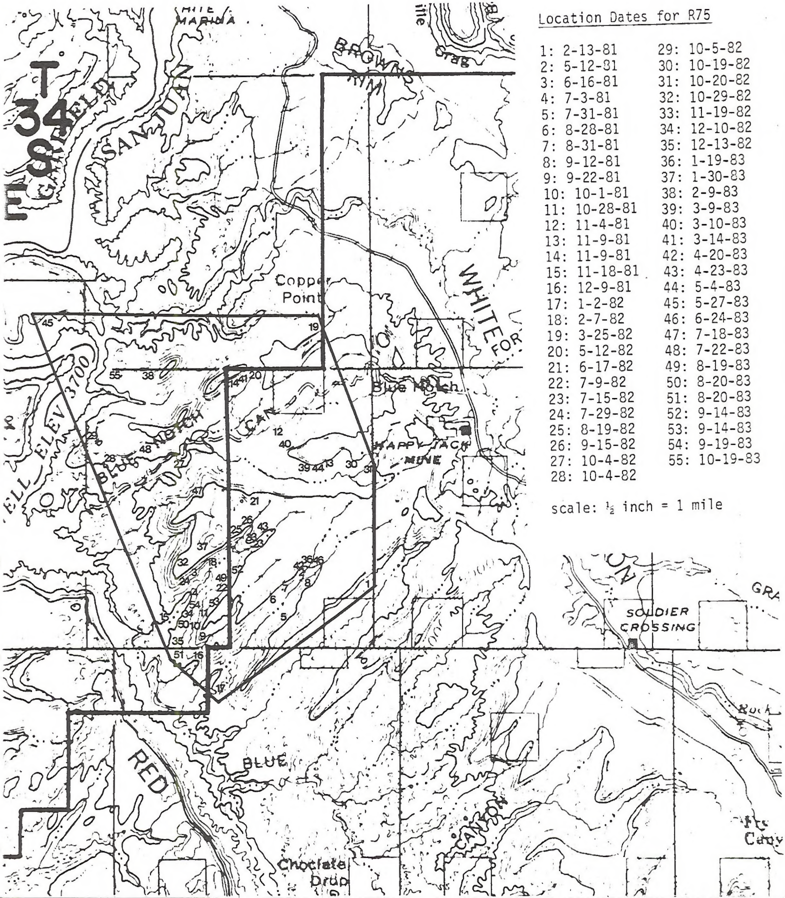


Figure 4. Home range area, individual locations and corresponding location dates for ram R135, 1981-1983.

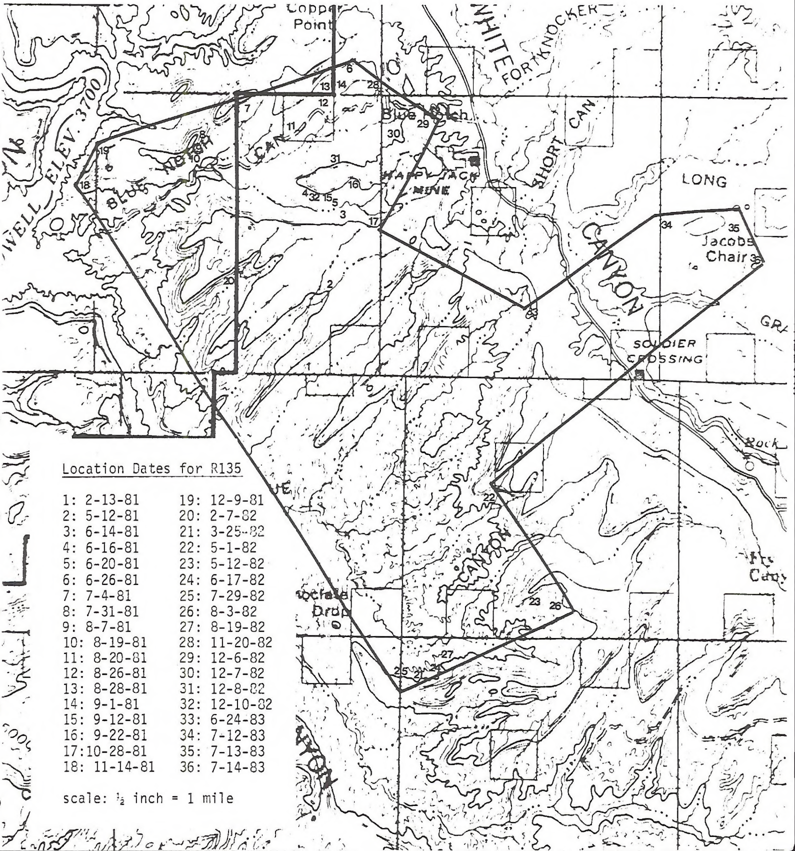
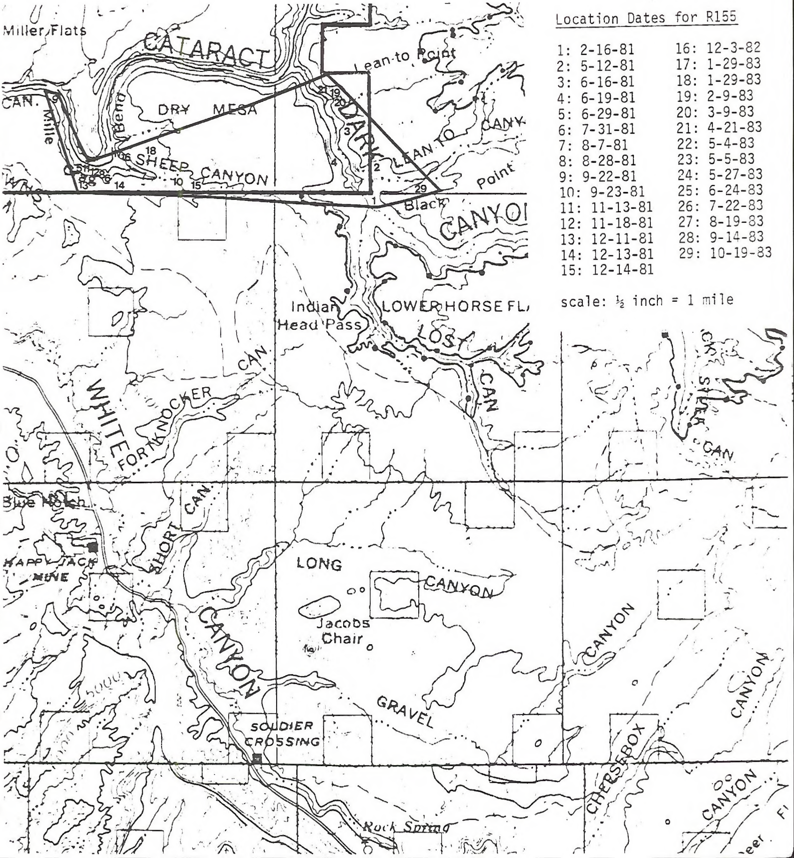


Figure 5. Home range area, individual locations and corresponding location dates for ram R155, 1981-1983.



Location Dates for R155

1: 2-16-81
2: 5-12-81
3: 6-16-81
4: 6-19-81
5: 6-29-81
6: 7-31-81
7: 8-7-81
8: 8-28-81
9: 9-22-81
10: 9-23-81
11: 11-13-81
12: 11-18-81
13: 12-11-81
14: 12-13-81
15: 12-14-81
16: 12-3-82
17: 1-29-83
18: 1-29-83
19: 2-9-83
20: 3-9-83
21: 4-21-83
22: 5-4-83
23: 5-5-83
24: 5-27-83
25: 6-24-83
26: 7-22-83
27: 8-19-83
28: 9-14-83
29: 10-19-83

scale: ½ inch = 1 mile

Figure 6. Home range area, individual locations and corresponding location dates for ram R130, 1983.

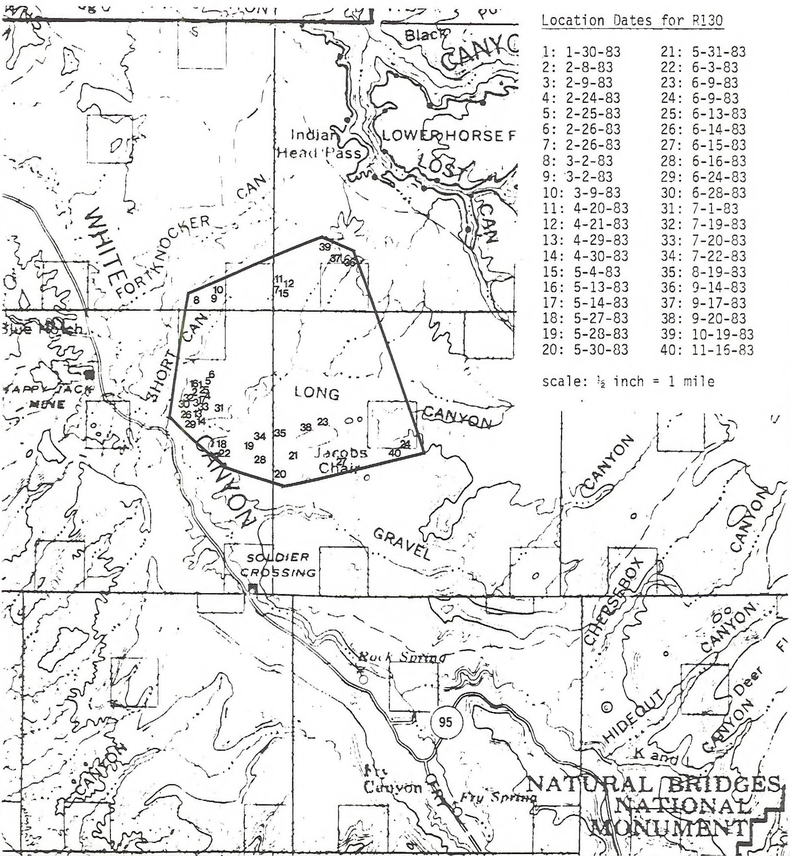


Figure 7. Home range area, individual locations and corresponding location dates for ram R355, 1983.

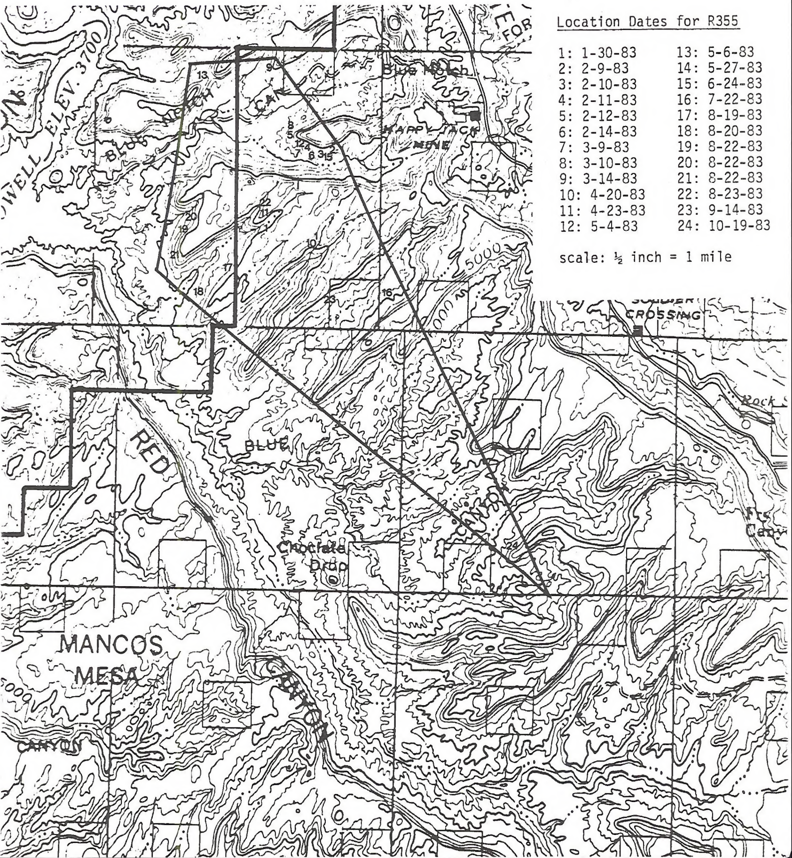
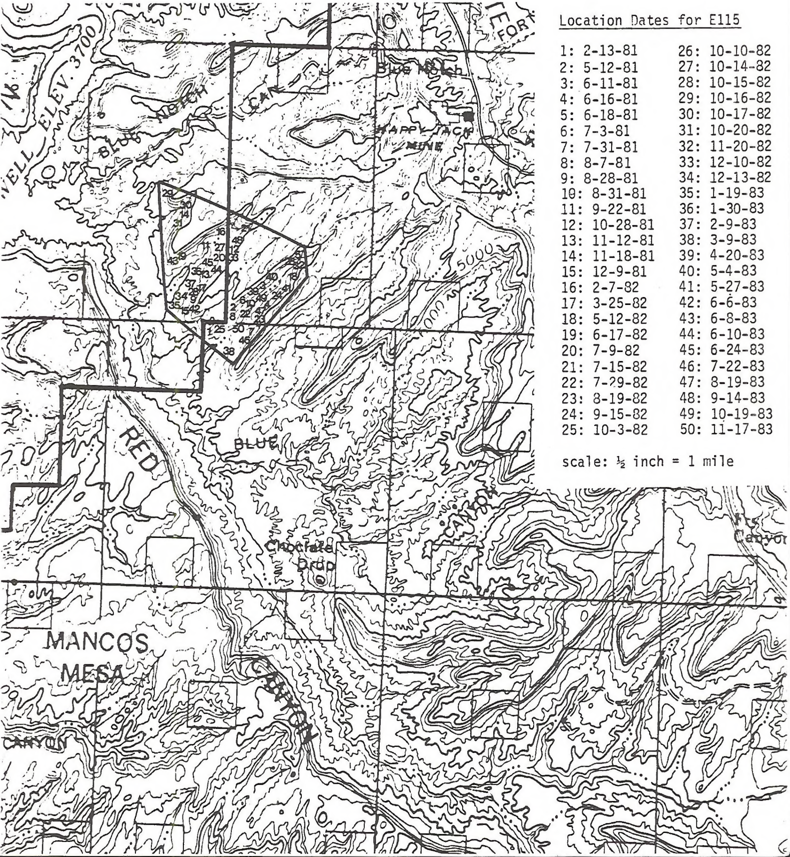


Figure 8. Home range area, individual locations and corresponding location dates for ewe E115, 1981-1983.

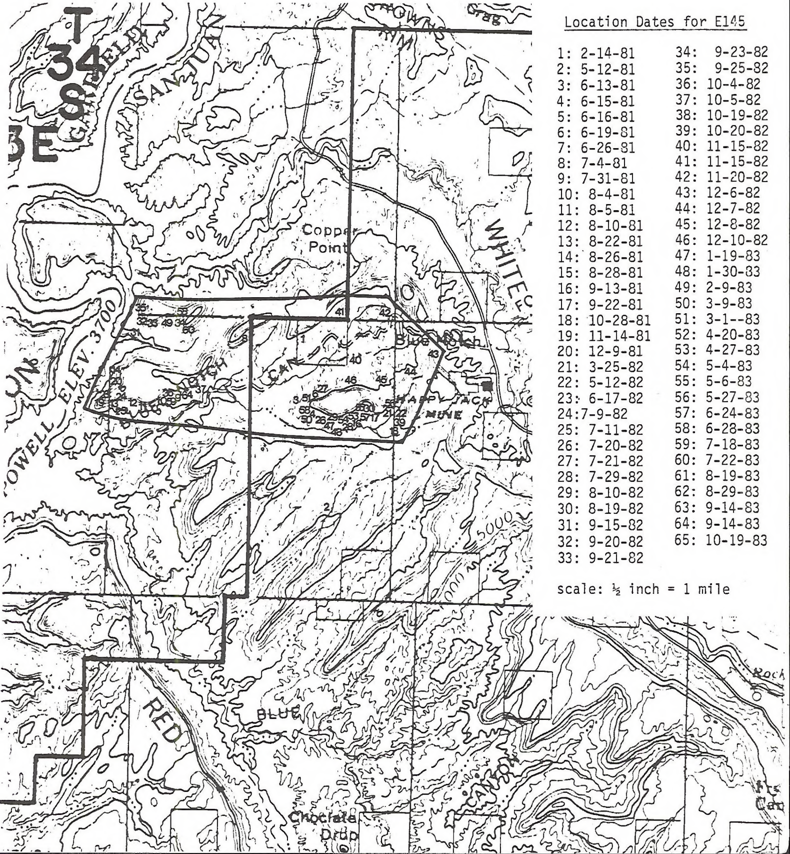


Location Dates for E115

1: 2-13-81	26: 10-10-82
2: 5-12-81	27: 10-14-82
3: 6-11-81	28: 10-15-82
4: 6-16-81	29: 10-16-82
5: 6-18-81	30: 10-17-82
6: 7-3-81	31: 10-20-82
7: 7-31-81	32: 11-20-82
8: 8-7-81	33: 12-10-82
9: 8-28-81	34: 12-13-82
10: 8-31-81	35: 1-19-83
11: 9-22-81	36: 1-30-83
12: 10-28-81	37: 2-9-83
13: 11-12-81	38: 3-9-83
14: 11-18-81	39: 4-20-83
15: 12-9-81	40: 5-4-83
16: 2-7-82	41: 5-27-83
17: 3-25-82	42: 6-6-83
18: 5-12-82	43: 6-8-83
19: 6-17-82	44: 6-10-83
20: 7-9-82	45: 6-24-83
21: 7-15-82	46: 7-22-83
22: 7-29-82	47: 8-19-83
23: 8-19-82	48: 9-14-83
24: 9-15-82	49: 10-19-83
25: 10-3-82	50: 11-17-83

scale: ½ inch = 1 mile

Figure 9. Home range area, individual locations and corresponding location dates for ewe E145, 1981-1983.



Location Dates for E145

1: 2-14-81	34: 9-23-82
2: 5-12-81	35: 9-25-82
3: 6-13-81	36: 10-4-82
4: 6-15-81	37: 10-5-82
5: 6-16-81	38: 10-19-82
6: 6-19-81	39: 10-20-82
7: 6-26-81	40: 11-15-82
8: 7-4-81	41: 11-15-82
9: 7-31-81	42: 11-20-82
10: 8-4-81	43: 12-6-82
11: 8-5-81	44: 12-7-82
12: 8-10-81	45: 12-8-82
13: 8-22-81	46: 12-10-82
14: 8-26-81	47: 1-19-83
15: 8-28-81	48: 1-30-83
16: 9-13-81	49: 2-9-83
17: 9-22-81	50: 3-9-83
18: 10-28-81	51: 3-1--83
19: 11-14-81	52: 4-20-83
20: 12-9-81	53: 4-27-83
21: 3-25-82	54: 5-4-83
22: 5-12-82	55: 5-6-83
23: 6-17-82	56: 5-27-83
24:7-9-82	57: 6-24-83
25: 7-11-82	58: 6-28-83
26: 7-20-82	59: 7-18-83
27: 7-21-82	60: 7-22-83
28: 7-29-82	61: 8-19-83
29: 8-10-82	62: 8-29-83
30: 8-19-82	63: 9-14-83
31: 9-15-82	64: 9-14-83
32: 9-20-82	65: 10-19-83
33: 9-21-82	

scale: ½ inch = 1 mile

Figure 10. Home range area, individual locations and corresponding location dates for ewe E80, 1982-1983.

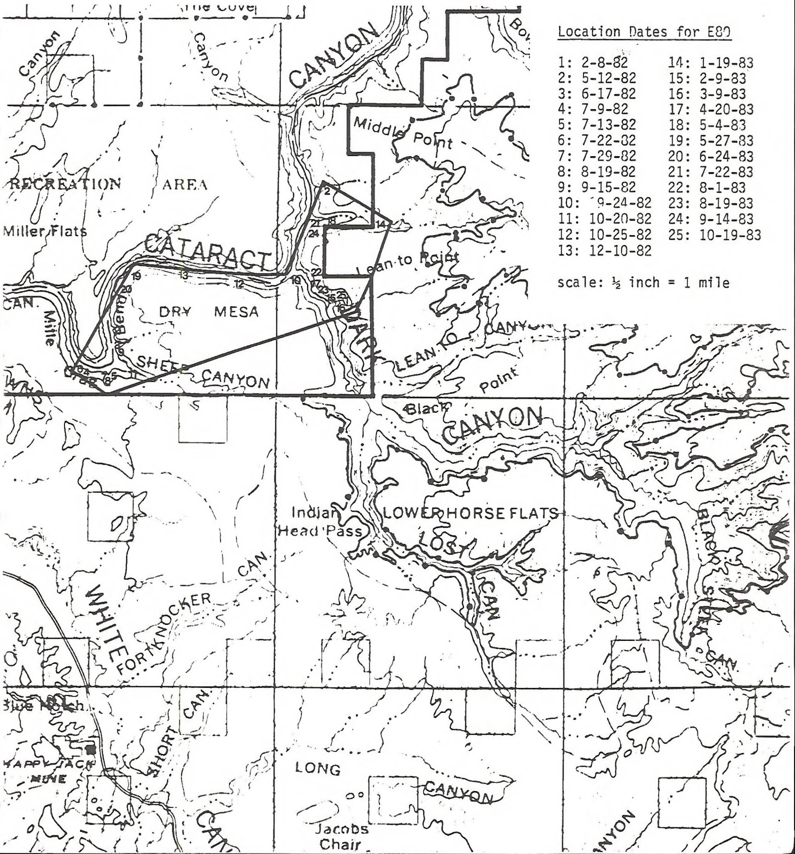


Figure 11. Home range area, individual locations and corresponding location dates for ewe E150, 1982-1983.

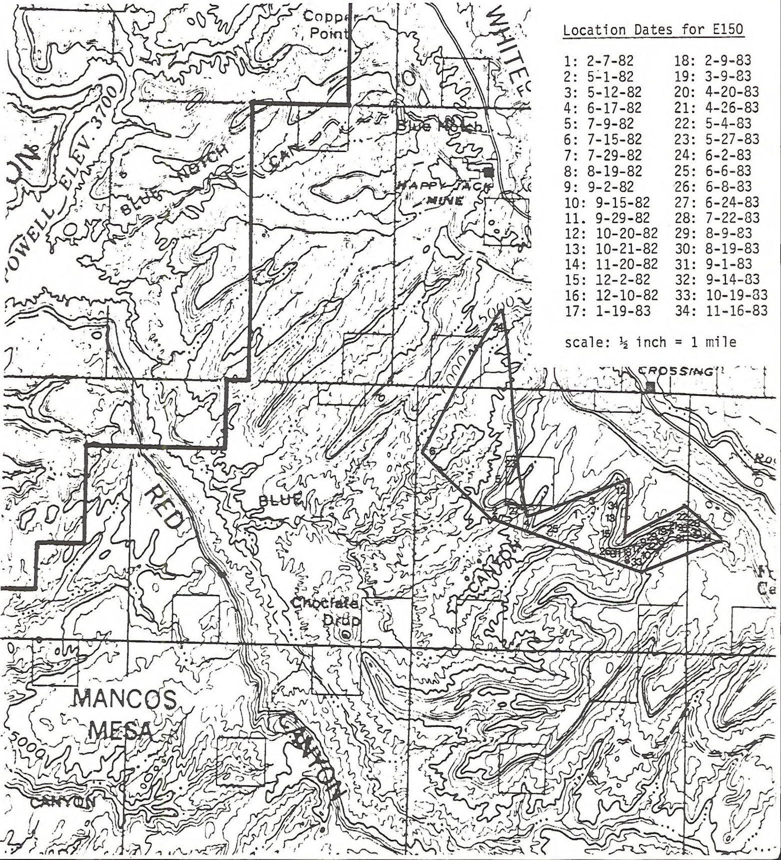
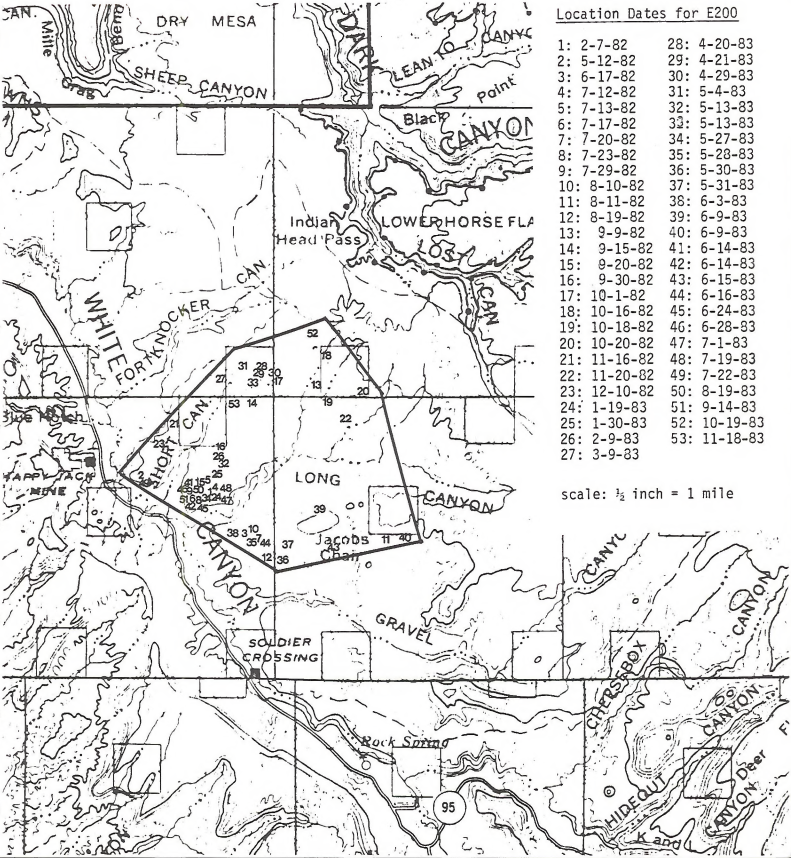


Figure 12. Home range area, individual locations and corresponding location dates for ewe E200, 1982-1983.

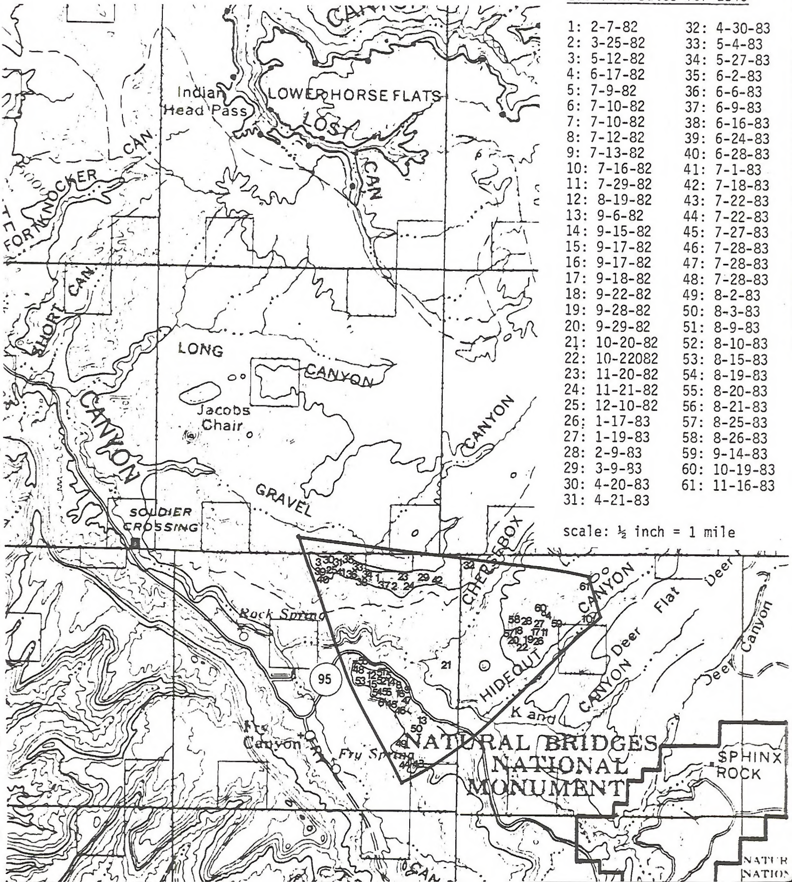


Location Dates for E200

1: 2-7-82	28: 4-20-83
2: 5-12-82	29: 4-21-83
3: 6-17-82	30: 4-29-83
4: 7-12-82	31: 5-4-83
5: 7-13-82	32: 5-13-83
6: 7-17-82	33: 5-13-83
7: 7-20-82	34: 5-27-83
8: 7-23-82	35: 5-28-83
9: 7-29-82	36: 5-30-83
10: 8-10-82	37: 5-31-83
11: 8-11-82	38: 6-3-83
12: 8-19-82	39: 6-9-83
13: 9-9-82	40: 6-9-83
14: 9-15-82	41: 6-14-83
15: 9-20-82	42: 6-14-83
16: 9-30-82	43: 6-15-83
17: 10-1-82	44: 6-16-83
18: 10-16-82	45: 6-24-83
19: 10-18-82	46: 6-28-83
20: 10-20-82	47: 7-1-83
21: 11-16-82	48: 7-19-83
22: 11-20-82	49: 7-22-83
23: 12-10-82	50: 8-19-83
24: 1-19-83	51: 9-14-83
25: 1-30-83	52: 10-19-83
26: 2-9-83	53: 11-18-83
27: 3-9-83	

scale: ½ inch = 1 mile

Figure 13. Home range area, individual locations and corresponding location dates for ewe E345, 1982-1983.

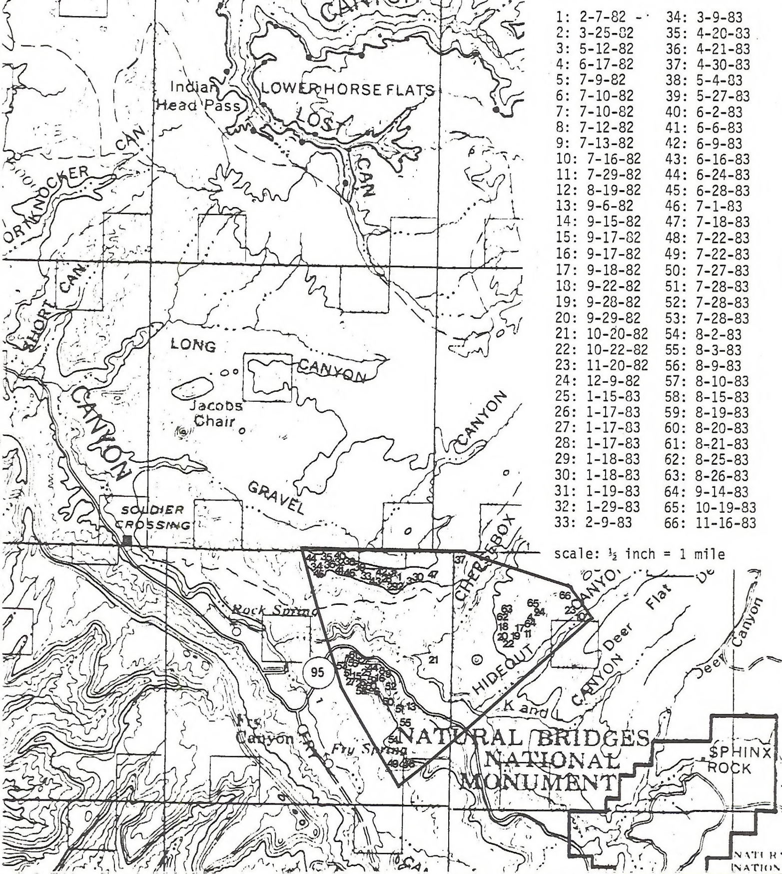


Location Dates for E345

1: 2-7-82	32: 4-30-83
2: 3-25-82	33: 5-4-83
3: 5-12-82	34: 5-27-83
4: 6-17-82	35: 6-2-83
5: 7-9-82	36: 6-6-83
6: 7-10-82	37: 6-9-83
7: 7-10-82	38: 6-16-83
8: 7-12-82	39: 6-24-83
9: 7-13-82	40: 6-28-83
10: 7-16-82	41: 7-1-83
11: 7-29-82	42: 7-18-83
12: 8-19-82	43: 7-22-83
13: 9-6-82	44: 7-22-83
14: 9-15-82	45: 7-27-83
15: 9-17-82	46: 7-28-83
16: 9-17-82	47: 7-28-83
17: 9-18-82	48: 7-28-83
18: 9-22-82	49: 8-2-83
19: 9-28-82	50: 8-3-83
20: 9-29-82	51: 8-9-83
21: 10-20-82	52: 8-10-83
22: 10-22082	53: 8-15-83
23: 11-20-82	54: 8-19-83
24: 11-21-82	55: 8-20-83
25: 12-10-82	56: 8-21-83
26: 1-17-83	57: 8-25-83
27: 1-19-83	58: 8-26-83
28: 2-9-83	59: 9-14-83
29: 3-9-83	60: 10-19-83
30: 4-20-83	61: 11-16-83
31: 4-21-83	

scale: ½ inch = 1 mile

Figure 14. Home range area, individual locations and corresponding location dates for ewe E365, 1982-1983.



Location Dates for E365

1: 2-7-82	34: 3-9-83
2: 3-25-82	35: 4-20-83
3: 5-12-82	36: 4-21-83
4: 6-17-82	37: 4-30-83
5: 7-9-82	38: 5-4-83
6: 7-10-82	39: 5-27-83
7: 7-10-82	40: 6-2-83
8: 7-12-82	41: 6-6-83
9: 7-13-82	42: 6-9-83
10: 7-16-82	43: 6-16-83
11: 7-29-82	44: 6-24-83
12: 8-19-82	45: 6-28-83
13: 9-6-82	46: 7-1-83
14: 9-15-82	47: 7-18-83
15: 9-17-82	48: 7-22-83
16: 9-17-82	49: 7-22-83
17: 9-18-82	50: 7-27-83
18: 9-22-82	51: 7-28-83
19: 9-28-82	52: 7-28-83
20: 9-29-82	53: 7-28-83
21: 10-20-82	54: 8-2-83
22: 10-22-82	55: 8-3-83
23: 11-20-82	56: 8-9-83
24: 12-9-82	57: 8-10-83
25: 1-15-83	58: 8-15-83
26: 1-17-83	59: 8-19-83
27: 1-17-83	60: 8-20-83
28: 1-17-83	61: 8-21-83
29: 1-18-83	62: 8-25-83
30: 1-18-83	63: 8-26-83
31: 1-19-83	64: 9-14-83
32: 1-29-83	65: 10-19-83
33: 2-9-83	66: 11-16-83

scale: ½ inch = 1 mile

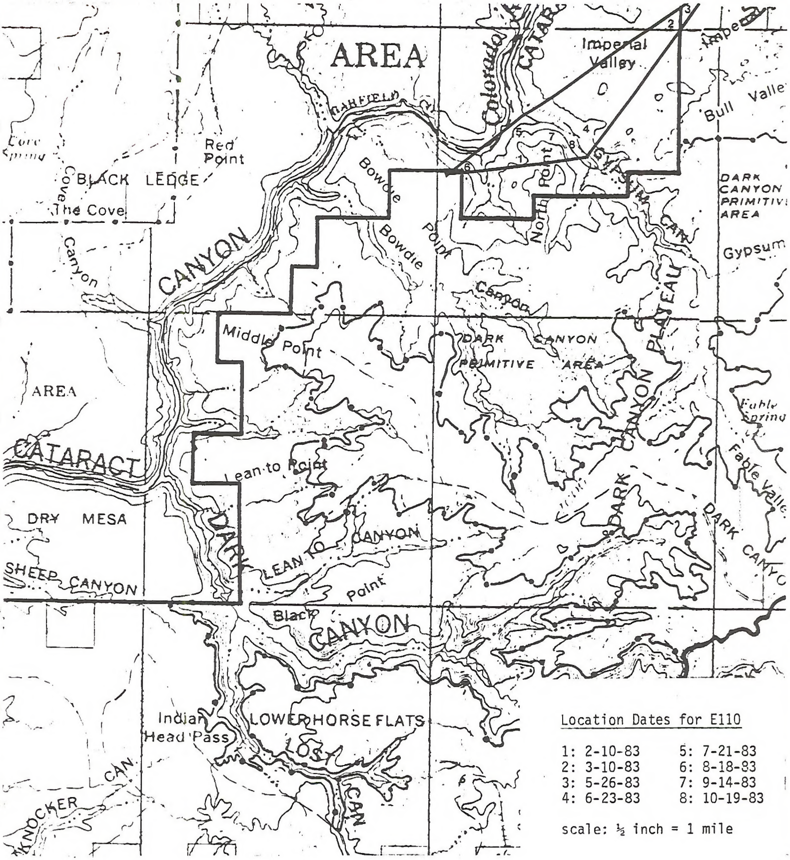
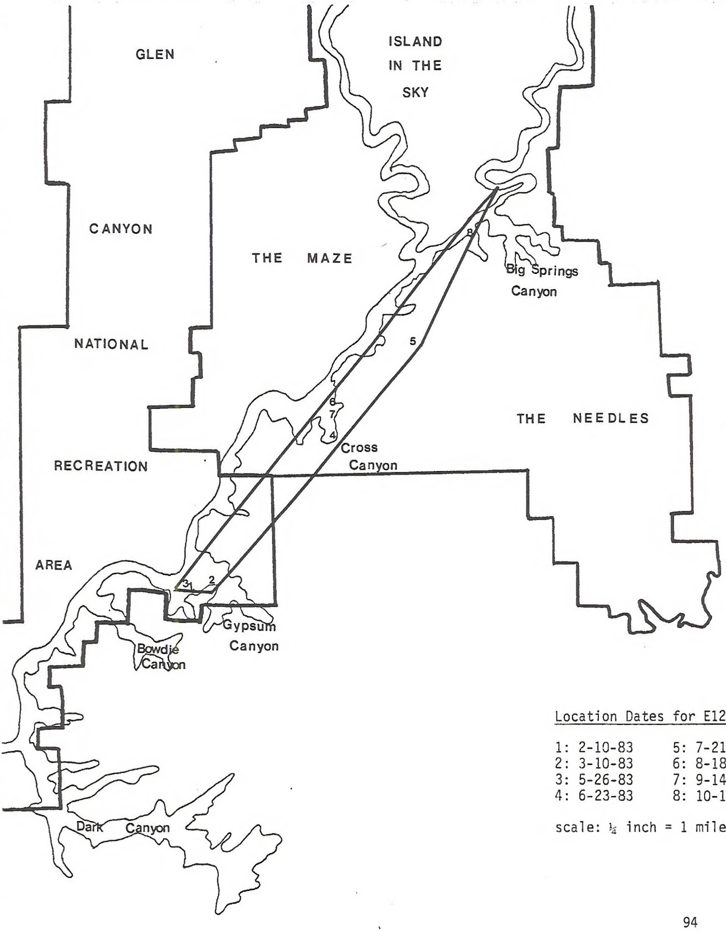


Figure 15. Home range area, individual locations and corresponding location dates for ewe E110, 1983.



Location Dates for E120

1: 2-10-83	5: 7-21-83
2: 3-10-83	6: 8-18-83
3: 5-26-83	7: 9-14-83
4: 6-23-83	8: 10-19-83

scale: ¼ inch = 1 mile

Figure 16. Home range area, individual locations and corresponding location dates for ewe E120, 1983.

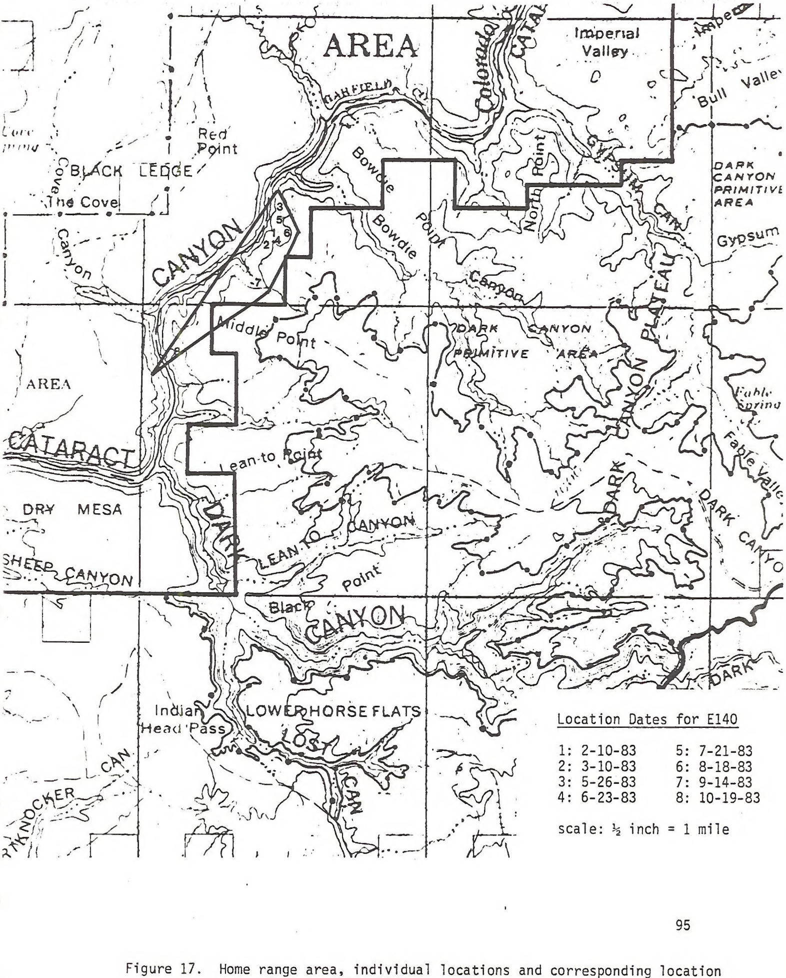


Figure 17. Home range area, individual locations and corresponding location dates for ewe E140, 1983.

Figure 18. Home range area, individual locations and corresponding location dates for ewe E170, 1983.

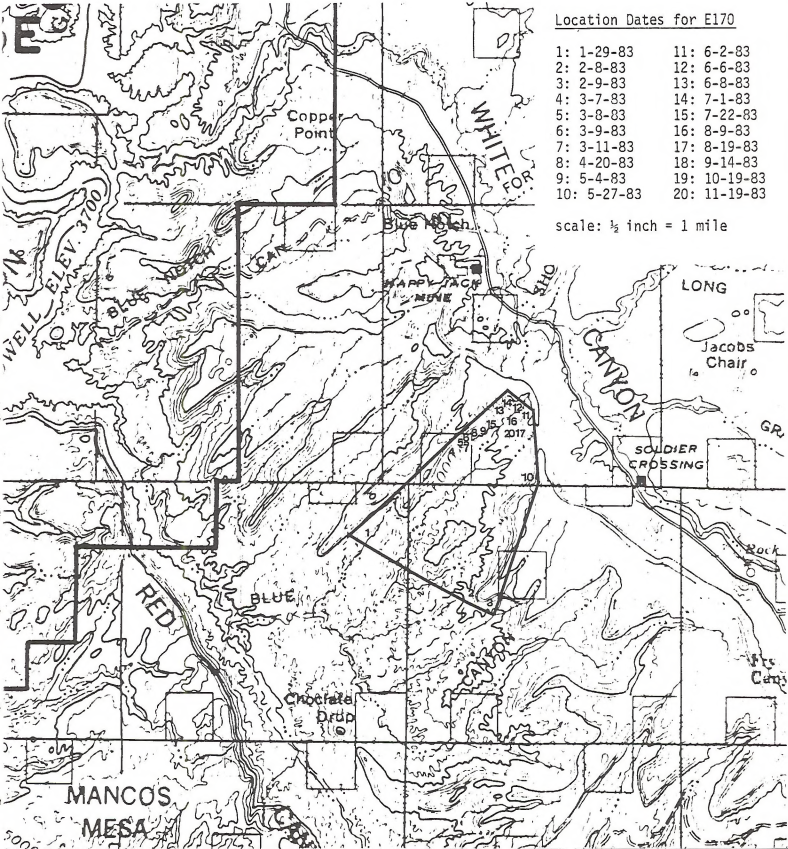


Figure 19. Home range area, individual locations and corresponding location dates for ewe E180, 1983.

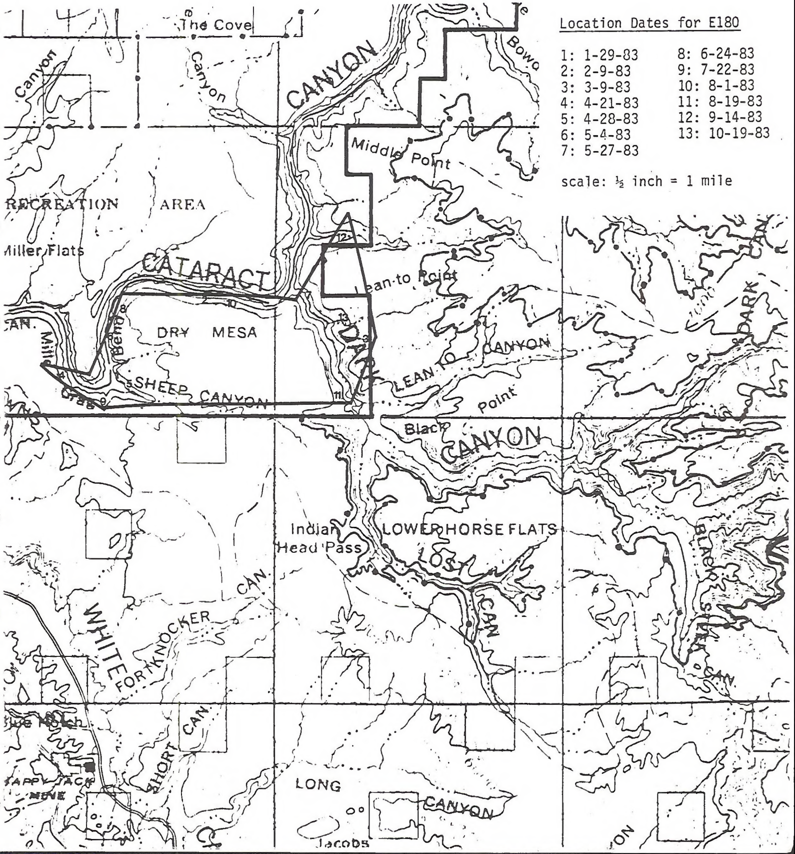


Figure 20. Home range area, individual locations and corresponding location dates for ewe E335, 1983.

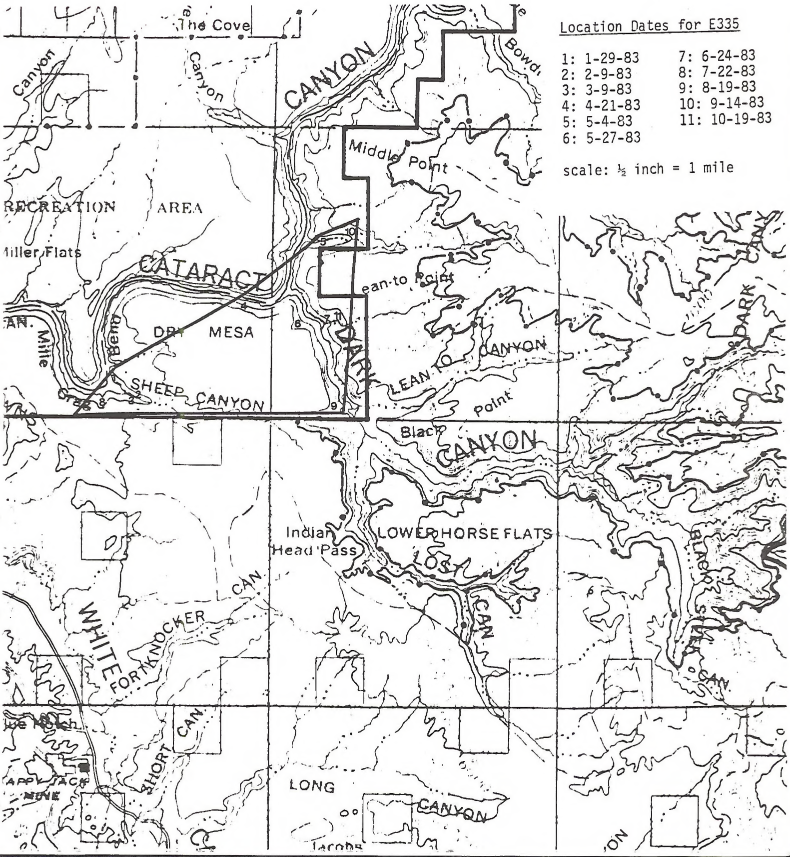
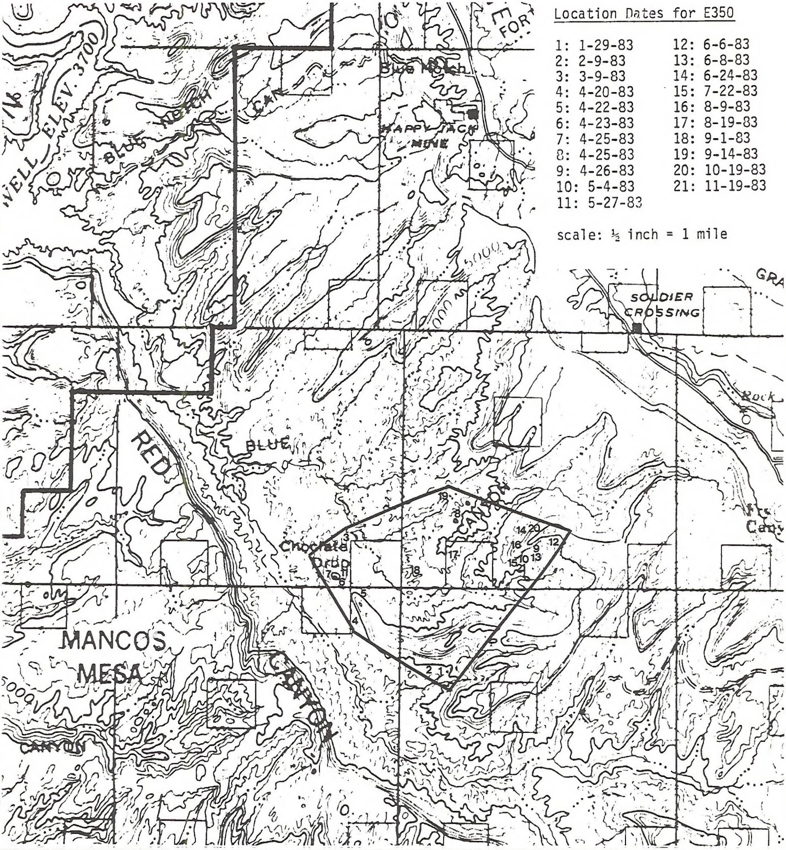
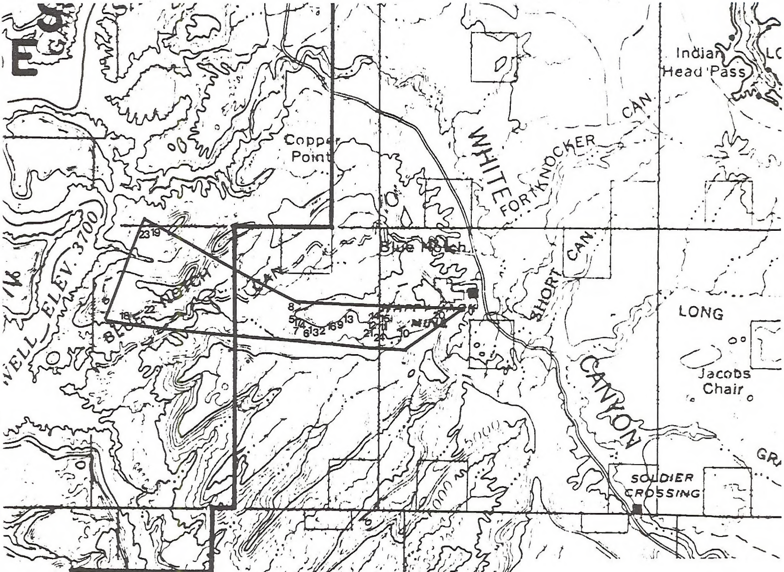


Figure 21. Home range area, individual locations and corresponding location dates for ewe E350, 1983.





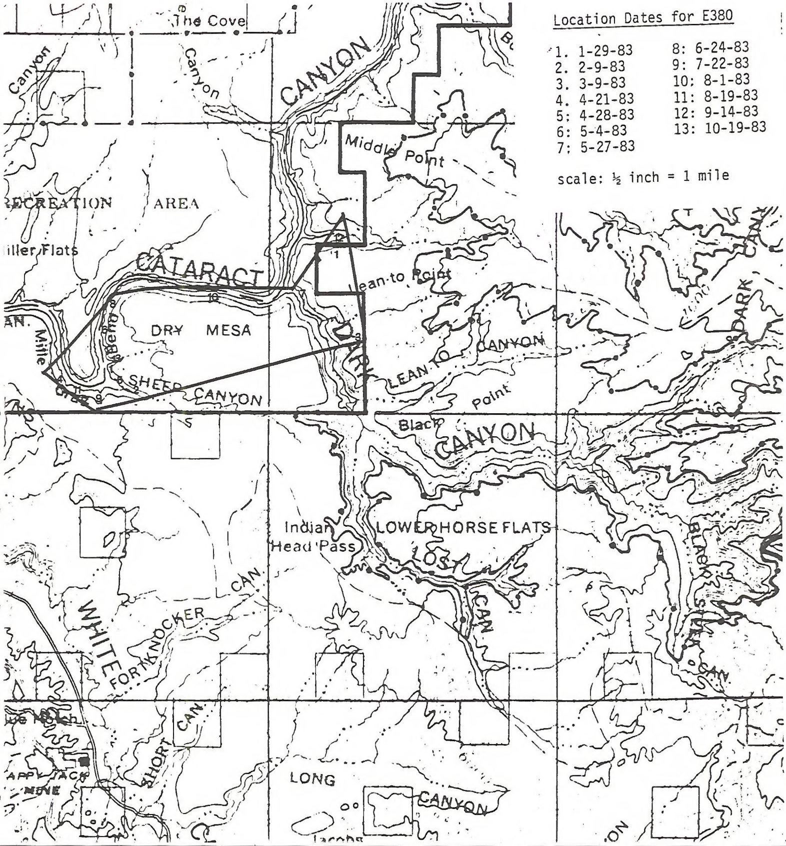
Location Dates for E370

1:1-30-83	14: 5-6-83
2: 2-9-83	15: 5-27-83
3: 2-10-83	16: 6-24-83
4: 2-11-83	17: 6-28-83
5: 2-12-83	18: 7-18-83
6: 2-14-83	19: 7-22-83
7: 3-9-83	20: 8-19-83
8: 3-10-83	21: 8-29-83
9: 4-20-83	22: 9-14-83
10: 4-27-83	23: 10-19-83
11: 4-28-83	24: 11-17-83
12: 4-29-83	
13: 5-4-83	

scale: ½ inch = 1 mile

Figure 22. Home range area, individual locations and corresponding location dates for ewe E370, 1983.

Figure 23. Home range area, individual locations and corresponding location dates for ewe E380, 1983.



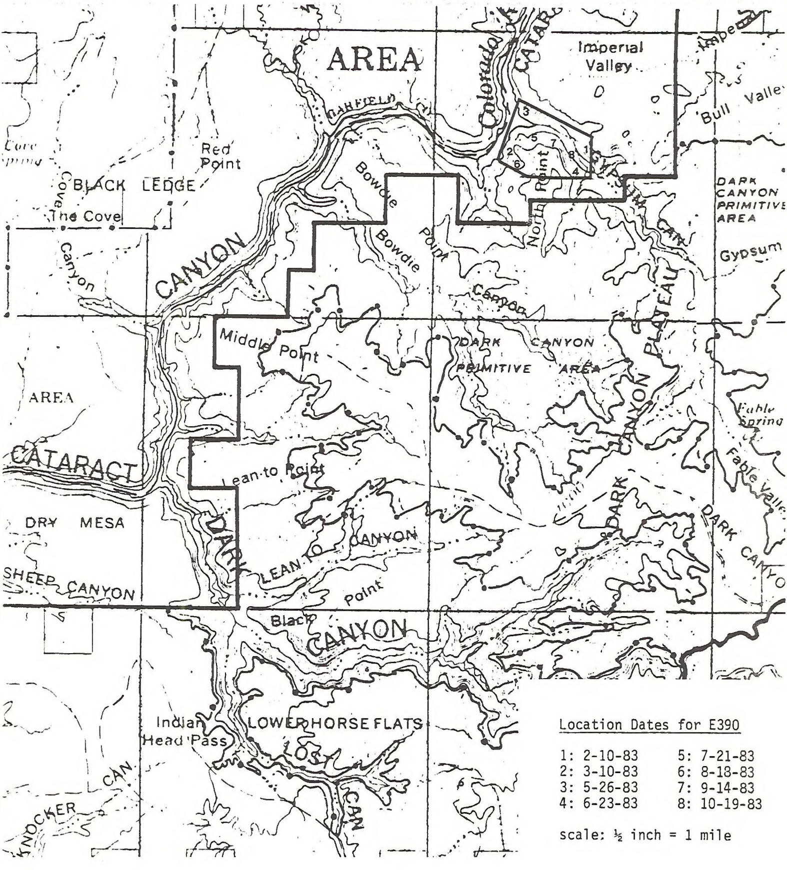


Figure 24. Home range area, individual locations and corresponding location dates for ewe E390, 1983.

Figure 25. Seasonal variation in percent composition of forage class in desert bighorn diets, 1983.

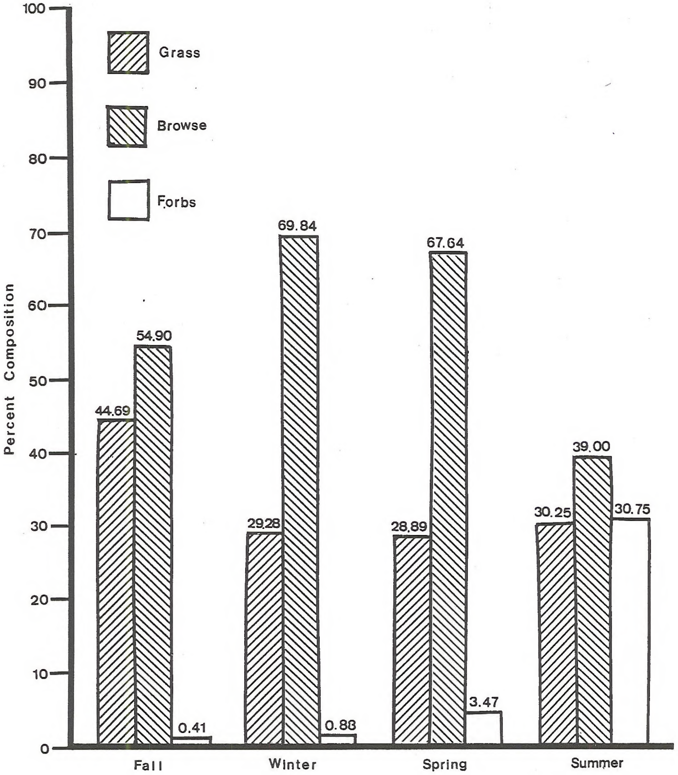


Figure 26. Generalized topographic types in the White Canyon area.

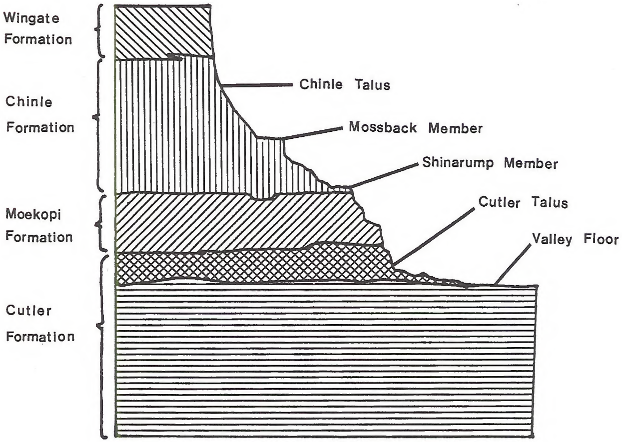


Figure 27 . Topographic types selected by bighorn and cattle in White Canyon during grazing season.

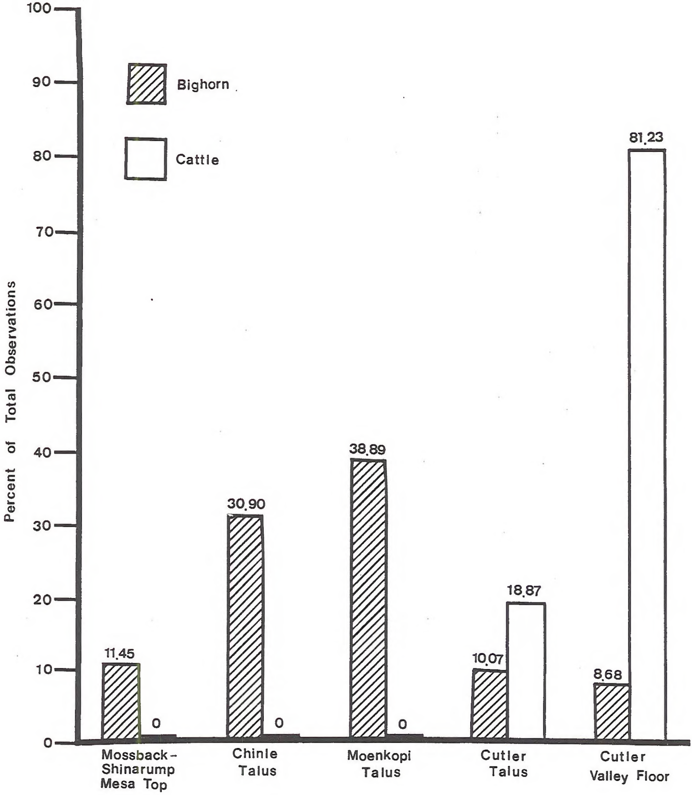


Figure 28. Percentage of forage class in diets of cattle and bighorn during grazing season (Nov.- Apr. 1981-82, 1982-83).

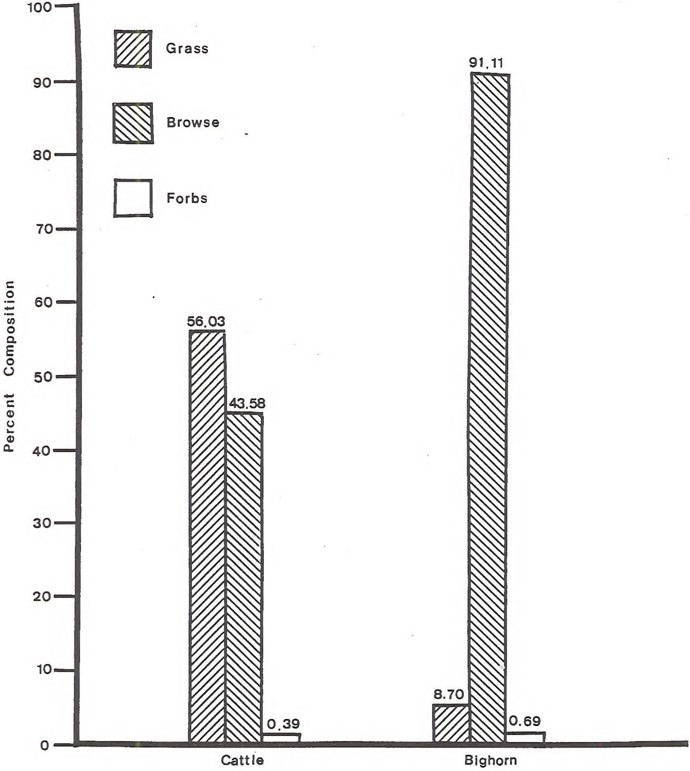
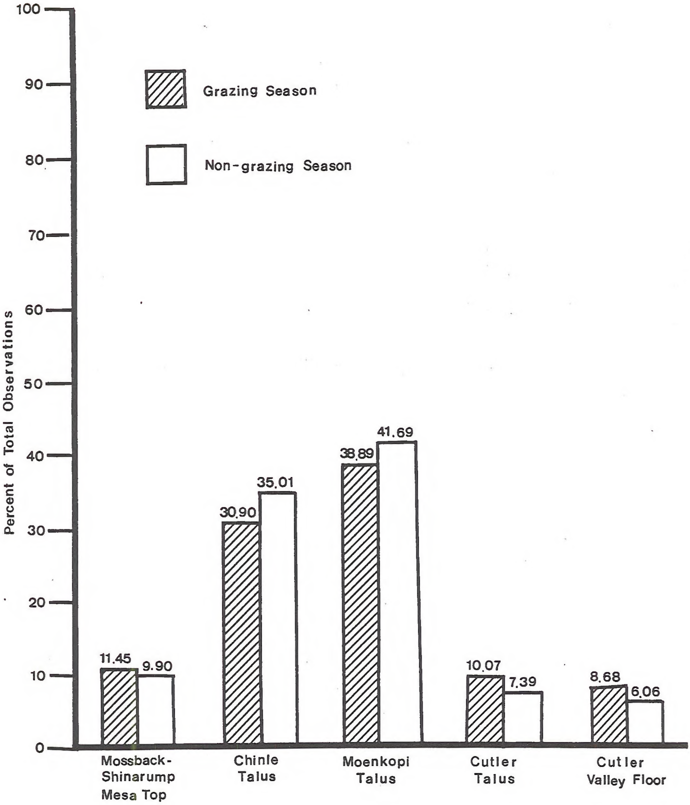


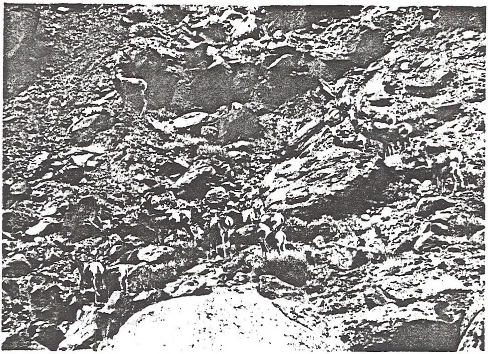
Figure 29. Topographic types selected by bighorn in White Canyon during grazing and non-grazing seasons.



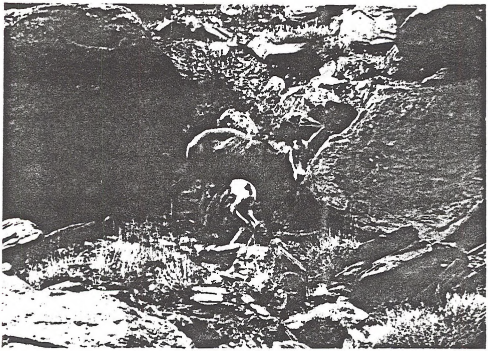
PHOTOGRAPHS

A group of foraging bighorn in the White Canyon area.

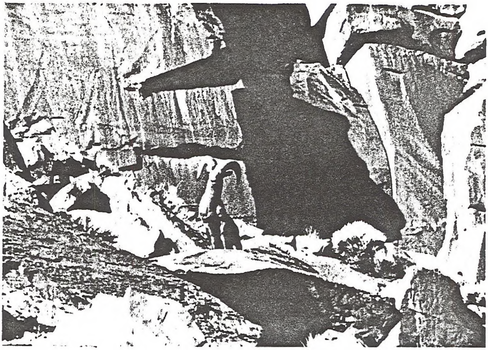
Lambs and ewes on the Jacob's Chair road.



Large group of ewes and lambs in Hidden Valley—an area commonly used by ewes during the lambing season.

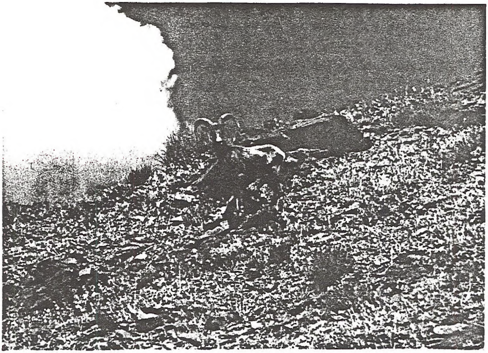


Mature ewe suckling her lamb in the Hidden Valley area.

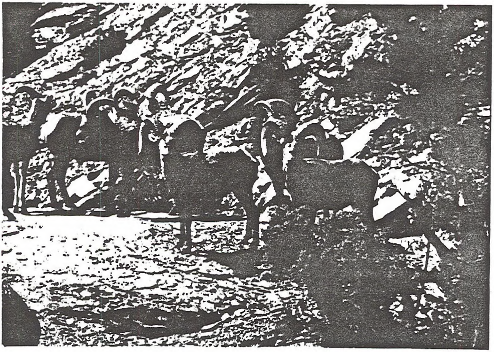


Large ram on Jacob's Chair Mesa, San Juan County, Utah.

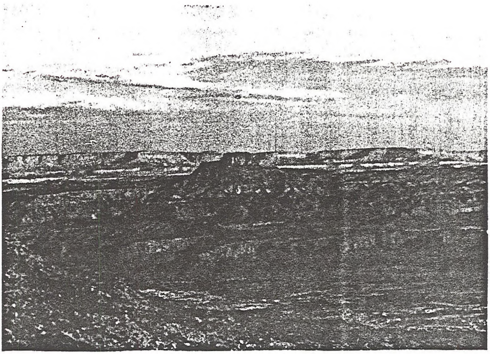
Mature rams live separately from ewes with the exception of the rut when they seek out estrous ewes.



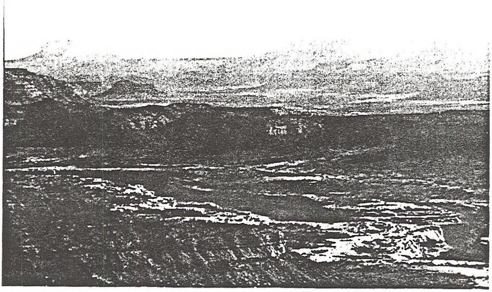
A three year old ram in Blue Canyon, San Juan County, Utah.

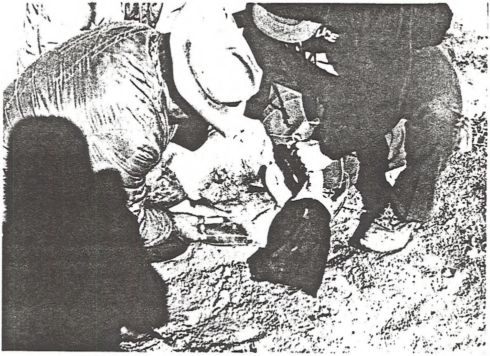


Rams often travel in groups during spring and summer.

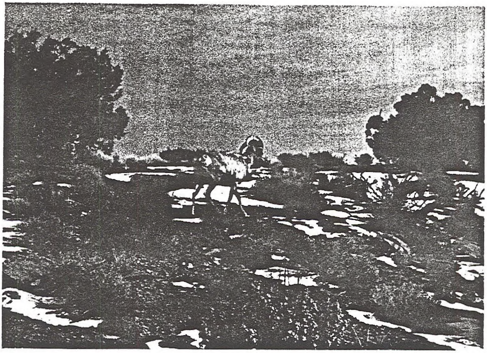


Typical habitat of desert bighorn sheep in White Canyon (above) and Gravel Canyon (below), San Juan County, Utah.

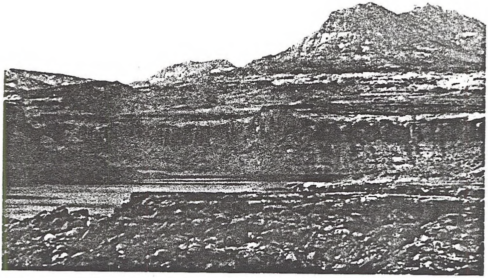




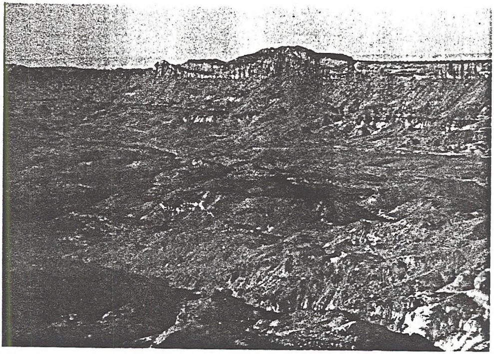
Blood samples were collected from all captured bighorn for serological analyses at USDA Veterinary Services Laboratories.

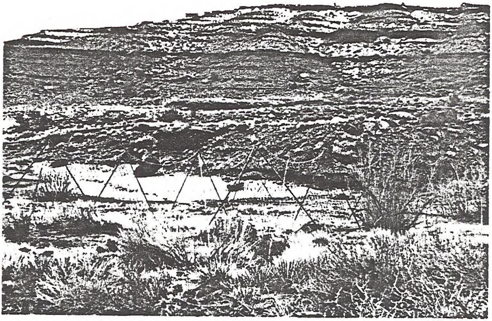


After desert bighorn are processed they are released at the capture site.



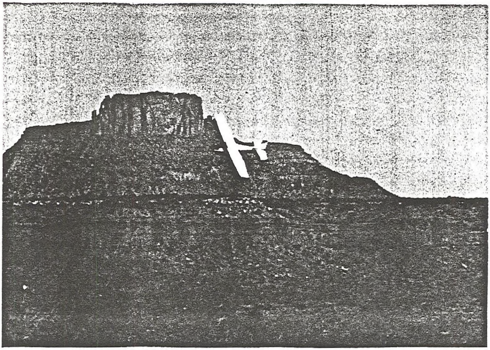
Typical habitat of desert bighorn sheep in Red Canyon (above) and Piute Canyon (below), San Juan County, Utah.



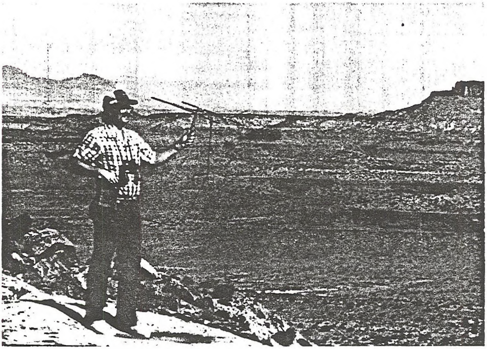


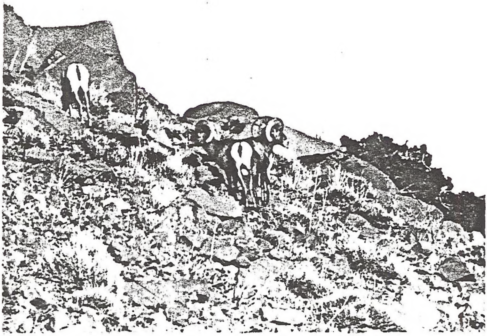
Bighorn were captured by driving them into tangle nets set in canyon or wash bottoms with a helicopter.

Bighorn are untangled from the nets and then restrained until radio-collars can be attached.

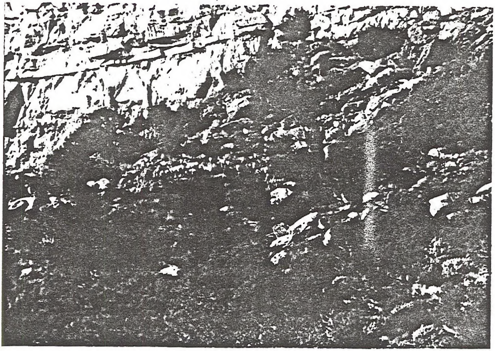


Radio-collared desert bighorn sheep are located from a fixed-wing aircraft (above) and by the researcher from the ground (below).

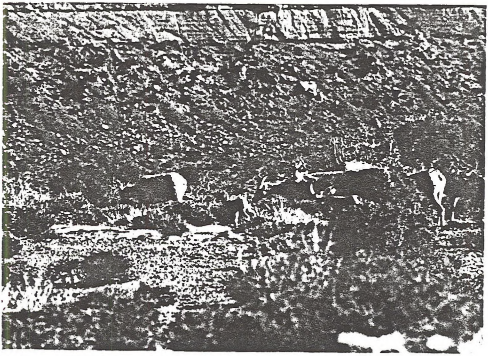




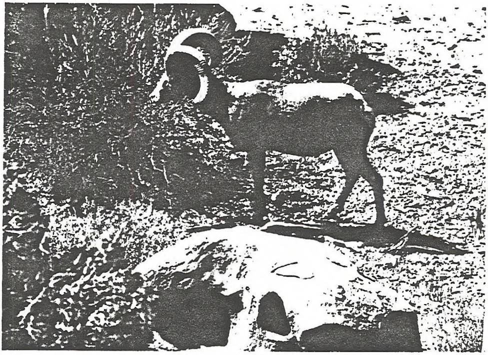
Desert bighorn select Chinle (above) and Moenkopi (below) talus slopes.



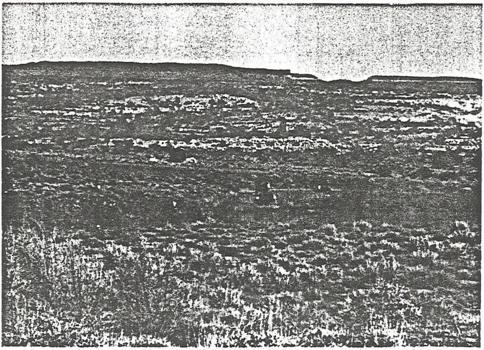
Lower Cutler talus slopes (above) and valley floors (below) are only used occaisionally by desert bighorn.



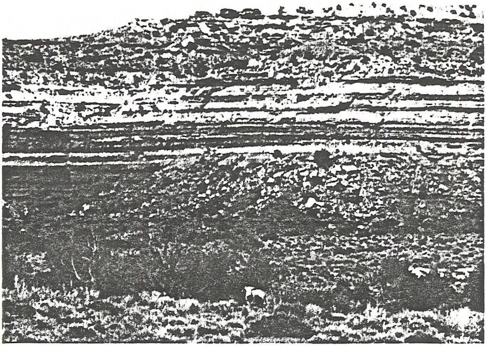
A group of ewes feeding on blackbrush.



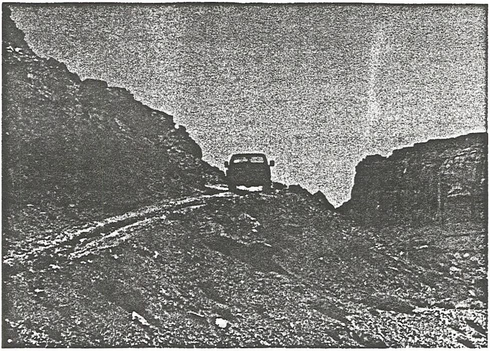
A mature ram feeding on cliffrose.



Cattle are generally located on valley floors in gentle terrain and near reservoirs in desert bighorn habitat.



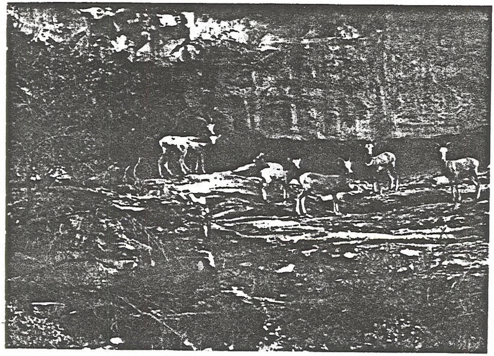
Lone cow on valley floor in White Canyon; bighorn use mesa tops and talus slopes in the background.



Many undeveloped roads cut through favorable bighorn habitat within the BLM desert bighorn study area.

One of nine trophy rams killed during the 1983 Utah desert bighorn hunt.

Float trips through Cataract Canyon are a popular form of recreation in bighorn habitat.



Typical reaction to rafts by bighorn along the Colorado River. Sheep generally don't flee unless boats land and people approach on foot.